Ground-water/Surface-water Interactions in the Upper Big Hole Basin, Montana

Report No. 192

MONTANA University System

WATER RESOURCES CENTER

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by

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Montana Tech

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Montana Bureau of Mines and Geology

Open-file Report

Ground-water/Surface-water Interactions in the Upper Big Hole Basin, Montana

MBMG 349

1997

GROUND-WATER/SURFACE-WATER INTERACTIONS IN THE UPPER BIG HOLE BASIN, MONTANA

Final Report

Submitted to:

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ABSTRACT

A preliminary ground-water/surface-water interaction study was conducted in the upper Big Hole basin of southwest Montana to address concerns about possible changes in stock-watering practices. Objectives of the project included characterizing the near-surface aquifer and obtaining estimates of water loss along surface-water diversions. Most wells in the basin are completed in poorly sorted Tertiary and Quaternary sand and gravel. Aquifer tests at five locations yielded hydraulic conductivity estimates of 0.02–1.1 ft/day. Ground-water flow in the basin is generally toward the Big Hole River, with another component of flow northward. On the average, ground-water levels across the basin rose 2.3 ft between May and June 1996. After July, levels dropped sharply. Larger than average water-level rises and declines generally were associated with flood irrigation and/or use of nearby surface-water diversions. Flow losses along 18 diversions were found to average 0.6 cfs/mile. Flow loss data were used to derive predictive equations for aquifer recharge near surface-water diversions. Flow loss and ground-water level data indicate that flood irrigation and surface-water diversion contribute significantly to the recharge of the basin's near-surface aquifer. This recharge may increase ground-water discharge to the surface-water system for as long as two months or as short as several days. The period of increased discharge strongly depends on ground-water flow distance and the hydraulic conductivity of the aquifer. Distance-drawdown calculations indicate that increased use of stock wells is unlikely to have a detrimental impact on ground-water/surface water interactions in the basin.

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INTRODUCTION

Project Background, Scope and Goals: In the upper Big Hole River basin of southwest Montana, using ground water to meet livestock needs is a management option that could be beneficial during drought years. Surface water that normally is diverted for stock could remain in natural drainages to maintain and protect trout fisheries and the last remaining fluvial Arctic grayling population in the continental United States. Stock needs could then be met with a network of strategically placed wells and stock tanks.

Many ranchers in the basin, however, are apprehensive about changing their traditional stock-watering practices. Concerns arise about available ground water in the basin and the interaction between the ground-water and surface-water systems.

Recognizing the need for a better understanding of the hydrology of the basin, the Beaverhead Conservation District (BCD), in cooperation with the Montana Bureau of Mines and Geology (MBMG), initiated a preliminary ground-water/surface-water (gw/sw) interaction study. The objectives of the project were as follows:

1) obtain data on the near-surface aquifer (lithology, depth to water, aquifer thickness, and hydraulic conductivity);

2) obtain estimates of water loss/gain along surface-water diversions; and

3) obtain other geologic and hydrologic information that furthers the understanding of the basin.

To accomplish these tasks, data collection included gathering surface-water stage and flow data from 18 diversions, logging the geology for 4 new stock wells, inventorying 108 wells, and tracking water-level fluctuations in select wells. Data collection for the project began in July 1995 and concluded in October 1996.

Study Area: The upper Big Hole basin encompasses approximately 1,200 mi^2 in western Beaverhead and southern Deerlodge counties in southwest Montana (figure 1). The basin is a wide, high-altitude valley bounded by mountains—the Beaverhead Mountains to the south and southwest, the Pioneer Mountains to the east, and the Anaconda (Pintler) Range to the north and northwest. The main stem of the Big Hole River flows northward through the valley, passing the communities of Jackson and Wisdom. Major tributaries in the area include the North Fork of the Big Hole, Warm Springs Creek, Governor Creek, Miner Creek, Swamp Creek, Little Lake Creek, Steel Creek, and Trail Creek.

Figure 1. Location map for the upper Big Hole River basin.

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the upper Big Hole River basin.

Big Hole River Flow Characteristics: Spring runoff in the upper basin usually begins in April and peaks in June. The average flow at Wisdom in June is 444 ft^3/second (cfs) (years 1988–1995, Shields *et al.* 1996). Discharge rapidly declines in July when precipitation decreases and most of the seasonal snowpack has melted. Flow is usually lowest during September, with a monthly average of 33 cfs (years 1988–1995, Shields *et al.* 1996).

Geology: The basin lies within the fold and thrust belt of the Northern Rocky Mountain physiographic province, which is characterized by numerous mountain ranges and intermontane valleys. The mountainous portions of the basin are predominantly Proterozoic metamorphic and Cretaceous igneous rocks (see figure 2). In the broad central portion of the basin, thin (<150 ft) Quaternary glacial till, outwash, and alluvial deposits overlie Tertiary sedimentary rocks. An exploratory well drilled by the American Oil Company in the early 1980s found more than 16,000 ft of Tertiary deposits in the center of the basin southwest of Wisdom (Levings 1986).

Climate: The climate of the upper basin is characterized by long, cold winters, mild summers, and low annual precipitation. Wisdom (elev. 6,060 ft) receives about 11 in. of precipitation annually (years 1961–1990, NOAA 1991), whereas the average annual precipitation in the adjacent mountains is 30–50 in. (SCS 1977). May and June typically are the wettest months.

Ranch
Gravel Pits
Numerous
small
lakes
CAMP MOUNTAIN
STEWART MOUN
DEER PEAK
JUMBO MOUNTAIN
PYRAMID PEAK
Rock Creek
Big Lake Creek
FOX GULCH
WOODY MOUNTAIN
BUTCH HILL
Jackson
Big Hole River
Governor
Twin Lakes
MONTANA
SQUAW MOUNTAIN
Big Swamp Cr
Little Lake Creek
Numerous small lakes
HOMER YOUNGS PEAK
Miner Creek
Hamby Creek
FREEMAN PEAK
Numerous small lakes
Fox Creek
CENTER MOUNTAIN
Pioneer Cr
BIG HOLE DIVIDE
Skinner Lake
Jahnke Cr
BEAVERHEAD CO
Map area
Scale 1:250,000
0
5
10 miles

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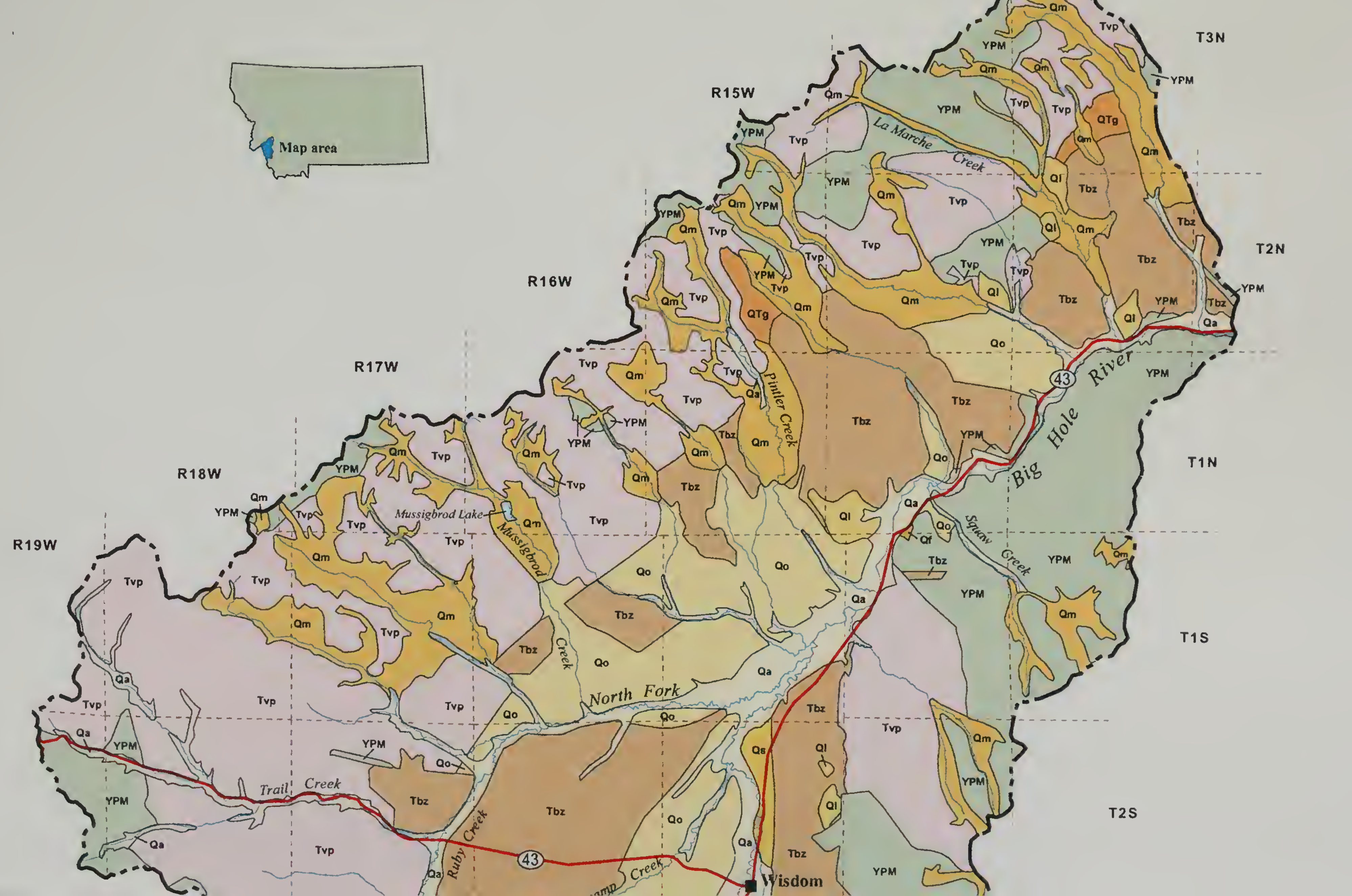
Figure 2. Generalized geologic map of the upper Big Hole basin

(modified from Ruppel *et al.* 1983 and Wallace 1987).



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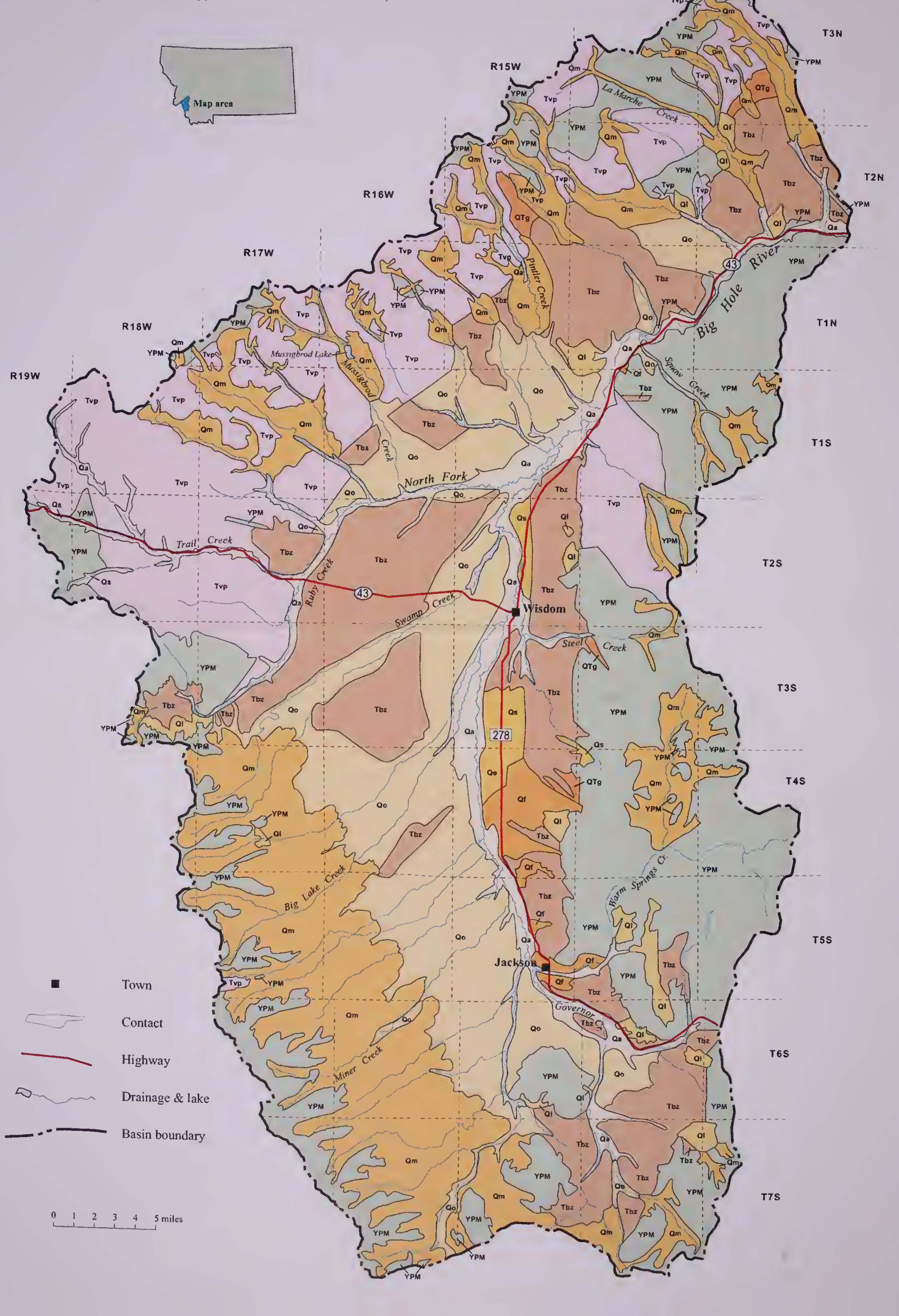


Legend for figure 2.
Geologic map for the upper Big Hole River basin

Qa Alluvium (Holocene) – Silt, sand, and gravel in channels and flood plains of major rivers and streams and in related alluvial fans. Maximum thickness unknown.

Ql Landslide deposits (Holocene and Pleistocene) – Angular fragments of bedrock mixed with soil or heterogeneous boulders and finer grained material derived from glacial deposits on steep valley walls; characterized by irregular, hummocky topography; boggy in places.

Qf Alluvial-fan deposits (Holocene and Pleistocene) – Poorly sorted silty sand and gravel deposited in broad alluvial fans along valley margins.

Qs Lacustrine sand and silt (Holocene and Pleistocene) – Silt and sand in thin-bedded, well-sorted deposits.

Qm Till (Pleistocene) – Unsorted mixture of boulders, cobbles, pebbles, and sand deposited by glaciers. Includes deposits of at least two, and in some places three, episodes of glaciation.

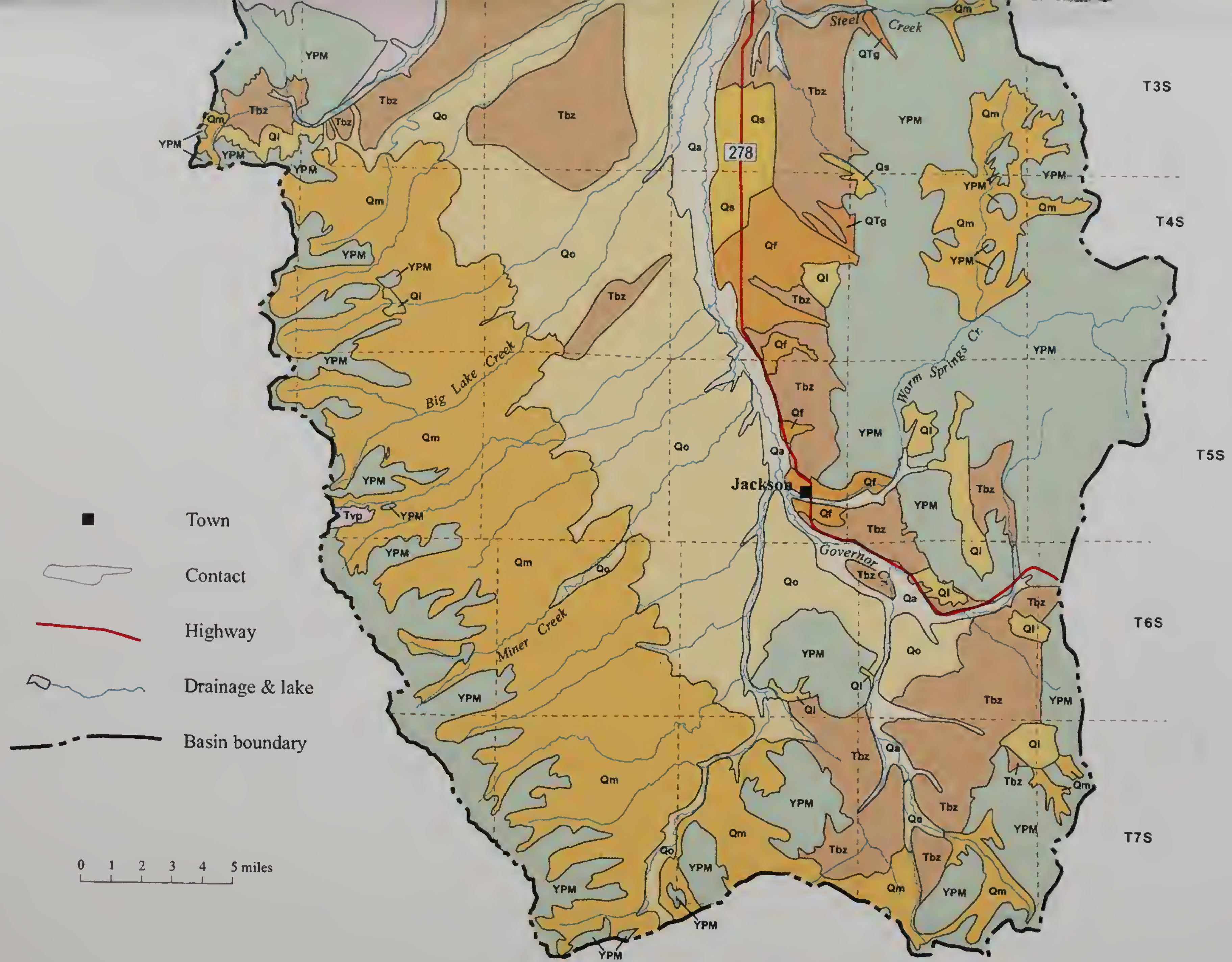
Qo Glacial outwash (Pleistocene) – Poorly sorted bouldery gravel and sand deposited by glacial meltwater.

Qtg Alluvial and pediment gravels (Quaternary and Tertiary) – Unconsolidated, deeply weathered angular to rounded pebbles, cobbles, and small boulders of quartzite, arkosic sandstone, and granitic rocks in sand matrix; commonly covered by a thin layer of eolian silt. Thickness 0–150 ft.

Tbz Bozeman Group and related valley-fill deposits, undivided (Pliocene to Eocene) – Light-gray to yellowish brown, moderately indurated to well-indurated tuffaceous sandstone and siltstone containing subordinate interbeds of limestone and marl and lenses of pebble and cobble conglomerate composed of locally derived rock fragments. Maximum thickness, in Big Hole basin, exceeds 16,000 ft.

Tvp Volcanic and plutonic rocks (Tertiary).

YPM Sedimentary rocks (Proterozoic, Paleozoic, and Mesozoic), and volcanic and plutonic rocks (Cretaceous).



T3S
T4S
T5S
T6S
T7S
Jackson
278
Steel Creek
Warm Springs Cr.
Big Lake Creek
Miner Creek
Governor Cr.
YPM
Qm
Tbz
Qo
Qa
Qs
Qf
Ql
QTg
Tvp
Town
Contact
Highway
Drainage & lake
Basin boundary
0 1 2 3 4 5 miles

Legend for figure 2.
Geologic map for the upper Big Hole River basin

Qa	Alluvium (Holocene) – Silt, sand, and gravel in channels and flood plains of major rivers and streams and in related alluvial fans. Maximum thickness unknown.
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Qo	Glacial outwash (Pleistocene) – Poorly sorted bouldery gravel and sand deposited by glacial meltwater.
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Tvp	Volcanic and plutonic rocks (Tertiary).
YPM	Sedimentary rocks (Proterozoic, Paleozoic, and Mesozoic), and volcanic and plutonic rocks (Cretaceous).

Because of the high altitude and thermal inversions, the basin is subject to extreme cold in the winter. Sub-zero temperatures are common during January and February. Summers are generally mild, with monthly average high temperatures ranging from 60 to 65 °F.

Water Use: The Big Hole River and its tributaries are the primary source of water for the approximately 112,000 acres of irrigated land in the upper basin (DNRC 1981). Generally, stream water is diverted into unlined ditches and canals to flood irrigate hay fields and pastureland. The irrigation season begins in May and continues through early July. Most diversions are closed by mid-July to let the fields dry for several weeks before the hay is harvested, though a few remain open to supply water to livestock. The quantity of water diverted for livestock is not well documented, but Montana Fish, Wildlife and Parks (MFWP) estimates that up to 60 cfs are diverted from the river above Wisdom during July, August, and September. This late-summer flow is the object of conflicting needs in some years.

Flows for fisheries and recreation are another source of water demand. MFWP estimates that 30–40 cfs are needed to maintain the fluvial Arctic grayling habitat near Wisdom during August and September. For the years 1988–1995, the average flow of the river during these months was 63 and 33 cfs, respectively (Shields *et al.* 1996).

GROUND WATER

A well inventory was conducted in the upper basin in the spring and summer, 1996. Data were gathered from 108 wells to characterize the hydrogeology of the basin's near-surface aquifer. Appendix A contains the summary data, including well locations, altitudes, depths, and water levels. Also, this information was entered into the MBMG's Ground-Water Information Center (GWIC) data base for use by future researchers and water resource managers. GWIC well identification numbers, or M:numbers, are used to reference well information throughout this report.

Hydrogeologic Units: Quaternary glacial till and outwash, alluvial deposits, and Tertiary sedimentary rocks are the primary hydrogeologic units in the broad, central portion of the basin where the study was focused. The Tertiary sedimentary rocks consist of sandstones, siltstones, and conglomerates that are exposed mostly along the flanks of the mountains.

Four stock wells (M:153310, M:153311, M:153312, and M:153313) drilled by the U.S. Fish and Wildlife Service in 1995 were completed in Tertiary siltstones underlying 80–200 ft of unconsolidated glacial outwash and Tertiary silt, sand, and gravel (see well logs, appendix B). Aquifer tests were performed on three of these wells (M:153310, M:153311, and M:153312) and one additional well near

Table 1: Data summary for aquifer tests.

Well ID M:Number	Location (Township, Range, Tract, Section)	Test Date	Test Type	Number of Tests	Well Depth (ft)	Aquifer	Screen Length (ft)	Depth to Water (ft)	Well Diameter (ft)	Screen Diameter (ft)	Hydraulic Conductivity (ft/day)	Analytical Method
M:107689	03S15W21DBDC01	5/8/96	Pump*	1	33	120SDMS	NA	10.88	0.5	NA	1.1	Thiem (1906)
M:108610	05S15W36CABD	8/29/95	Slug	2	36	120SDMS	6	23.11	0.5	0.33	0.029	Bouwer and Rice (1976)
M:153310	02S16W24ADBC	10/16/95	Slug	3	85	120SDMS	3	24.70	0.5	0.33	0.020	Bouwer and Rice (1976)
M:153311	02S16W25ABAB	10/20/95	Slug	1	203	120SDMS	0.1	32.84	0.5	0.33	0.57	Kipp (1985)
M:153312	02S16W07CDAC	10/20/95	Slug	3	115	120SDMS	39	38.10	0.5	0.33	0.036	Bouwer and Rice (1976)
										Average:	0.35	

Notes:

NA Not available

* Steady state conditions, 10 gpm

Aquifer: 120SDMS = Tertiary sediments

meltwater, consists of poorly sorted lenses of cobbles, gravel, and sand. The glacial outwash is as much as 100 ft thick near the upstream source areas but thins down basin. Using the specific capacities of seven wells, Levings (1986) estimated that the outwash materials have a median transmissivity of 550 ft^2/day.

Recharge: Recharge to the ground-water system is principally from infiltration of precipitation on the land surface, and from infiltration of runoff in stream channels, unlined diversions, and flood-irrigated hay meadows. Seasonal recharge to the ground-water system generally begins in early spring and ceases by mid-summer as mountain snow pack and runoff decrease and evapotranspiration (ET) increases (Levings 1986).

Direction of Ground-Water Movement: The direction of ground-water movement in the valley is depicted on plate 1, a potentiometric surface map of shallow ground water in the upper Big Hole basin. Contours were developed from water-level measurements made during the spring and summer 1996; historical data from GWIC also were used if a field measurement was not possible. Altitudes of perennial surface-water features were used in conjunction with the well data. Plate 1 is very similar to the potentiometric surface map produced by Levings (1986) with data from 1982 and 1983. The similarity suggests that increased ground-water use and any other changes in aquifer

recharge and/or discharge over the past 13–14 years have had little effect on the the basin's ground-water supply.

Ground-water flow in the basin is generally toward the Big Hole River, with another component of flow northward. At the north end of the basin, all ground-water flow in the Quaternary and Tertiary beds is toward the river.

Horizontal gradients west of the Big Hole River are lower than those on the east, reflecting the relatively gentle topography on the west side of the basin. From south to north along the western side of the study area, the potentiometric gradient decreases from about 0.02 to 0.005 ft/ft. The decrease may result from an increase in the thickness and/or hydraulic conductivity of the aquifer.

Flow in the basin aquifer also has a vertical component. Upward gradients occur along the main stem of the Big Hole and several tributaries as evidenced by the presence of nine artesian wells (table 2). These wells range from 6 to 200 ft deep; flow rates are as much as 10 gpm. A water level from one of the artesian wells (M:108583) was compared to that of a nearby shallow well (M:156225) to obtain an upward gradient estimate of 0.18 ft/ft (table 3).

On the benches and terraces away from the river and tributaries, gradients are generally downward. Using three well pairs that were inventoried in such areas,

Table 2: Artesian wells in the upper Big Hole basin.

Well ID M:Number	Location (Township, Range, Section, Tract)	Land Surface Elevation (ft)	Well Depth (ft)	Water Level Elevation (ft)	Comments
M:107684	03S15W20CDAC	6138	33	6139.4	WL above ground surface
M:108583	05S15W03BDCB	6319	66	6319	Flowing
M:145348	04S15W05DBCD	6195	26	6195.6	WL above ground surface
M:156194	01S16W21ADCC01	6180	6	6180	Flowing
M:156220	04S16W04ACCC	6340	--	6342	Flowing
M:156224	04S16W17BABA	6520	--	6516.4	Seasonal flow
M:156227	05S15W34BCAD	6500	--	6503	WL above ground surface
M:156230	06S15W06ADAA	6625	--	6625	Flowing
M:151289	01N14W27ABDD	5910	200	5910	Flowing, but grouted after inventory

Notes:
-- Not available

vertical gradients in the aquifer were found to range from 0.06 to 0.18 ft/ft (table 3). The vertical gradients fluctuate seasonally, with the highest gradients during the early summer when recharge from runoff and irrigation generally occurs.

Water-Level Fluctuations: Water levels in about 30 wells were monitored monthly from May through August 1996 to characterize the seasonal fluctuation in the basin aquifer (see appendix C). Two wells, M:153310 and M:108610, were equipped with continuous recorders for long-term monitoring. On the average, water levels across the basin rose approximately 2.3 ft from mid-May to mid-June (see figure 3). From June to July, levels declined by about 0.3 ft. After July, water levels in the aquifer declined sharply, returning to levels slightly higher than those in May.

Temperature and precipitation data (NWS 1996) from Wisdom during January through September 1996 are presented in figures 4 and 5, respectively. These data are compared to the monthly averages for the 30 years of record from 1961 to 1990. As shown, temperatures during winter, spring, and summer 1996 were close to normal, and precipitation was about 1.6 in. (15%) greater than average. Using these data as approximate indicators of ET and recharge, it was concluded that no highly unusual climatic conditions occurred that would have affected water levels in the basin aquifer. Therefore, water-level fluctuations observed during the study were probably close to normal.

Table 3: Vertical gradients in the upper Big Hole basin.

Well Pairs (Shallow/Deep):	M:156203	M:156202		M:156201	M:145340		M:107689	M:107688		M:156225	M:108583	
Surface Elevation (ft):	6050	6050		6050	6050		6150	6150		6317	6319	
Total Depth (ft):	31	44		10	60		33	81		38	66	
Well Bottom Elevation (ft):	6019	6006		6040	5990		6117	6069		6279	6253	
Month, 1996	Water Levels (ft)		Gradient	Water Levels (ft)		Gradient	Water Levels (ft)		Gradient	Water Levels (ft)		Gradient
May	6043.2	6040.9	0.18	6043.4	6040.2	0.06	–	–	–	6315.2	6320*	-0.18
June	6044.5	6043.7	0.06	6047.1	6042.0	0.10	6149.3	6142.0	0.15	–	–	–
July	6044.2	6043.2	0.08	6046.3	6041.4	0.10	6148.3	6142.7	0.12	–	–	–
August	6043.2	6042.2	0.08	6042.7	6039.6	0.06	6145.9	6140.6	0.11	–	–	–
October	6042.1	6041.1	0.07	–	–	–	–	–	–	–	–	–
Average Vertical Gradient:			0.09			0.08			0.13			-0.18

Notes:
Vertical gradient sign convention: + down, - up
– No measurement
* Flowing well. Water level estimated.

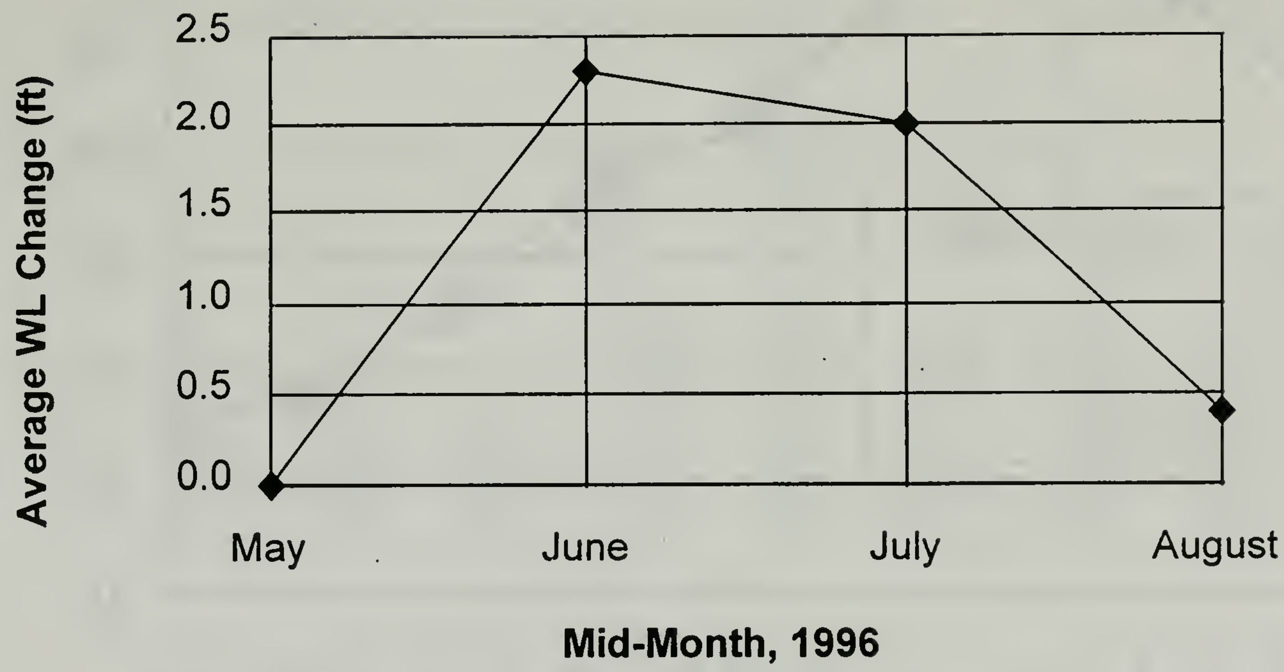


Figure 3. Hydrograph of average water-level changes in the upper Big Hole basin aquifer, May–August, 1996. Change is relative to water levels in May.

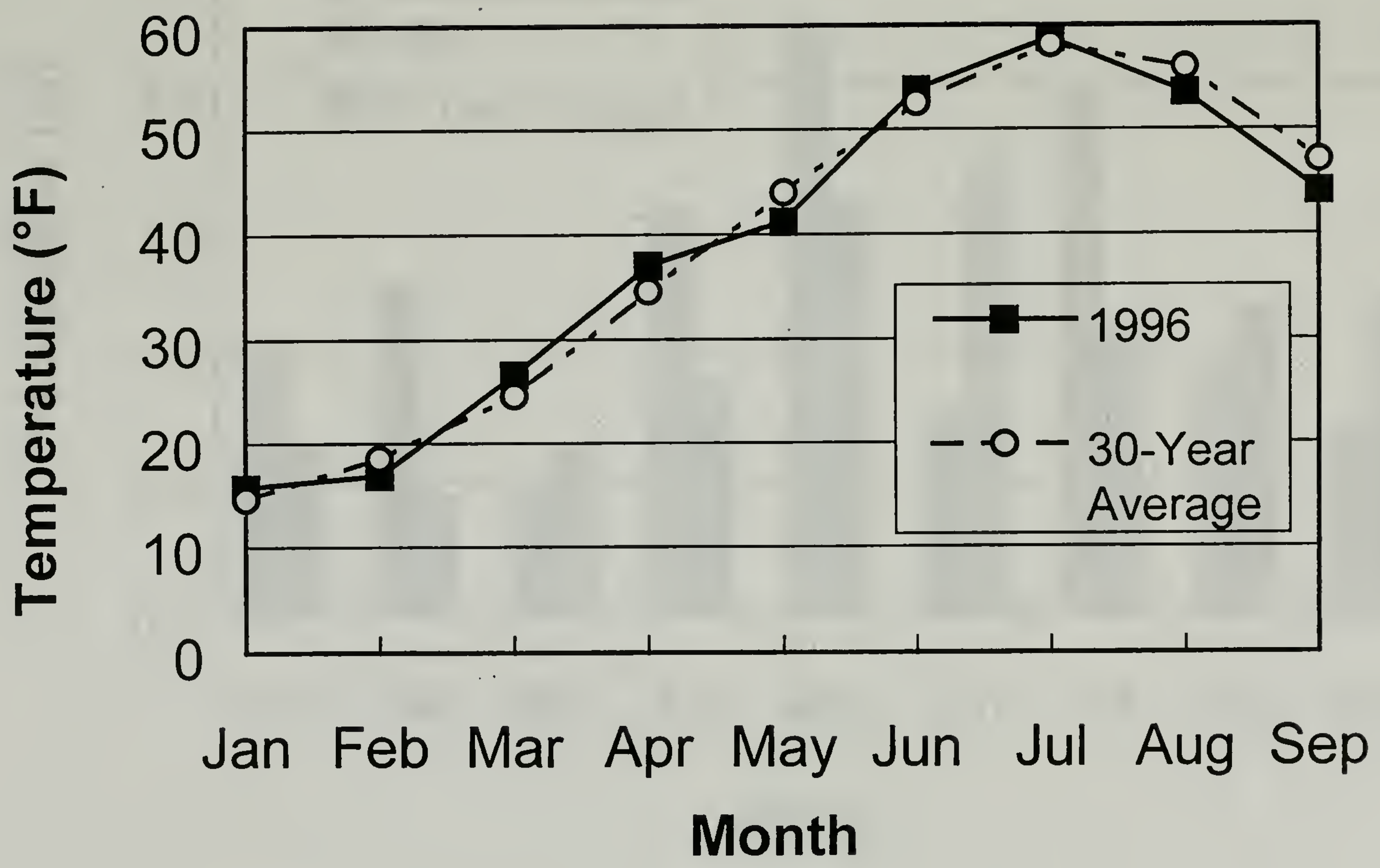


Figure 4. Average monthly temperatures, 1996 and 30-year average, Wisdom, Montana. Data from NOAA (1991) and NWS (1996).

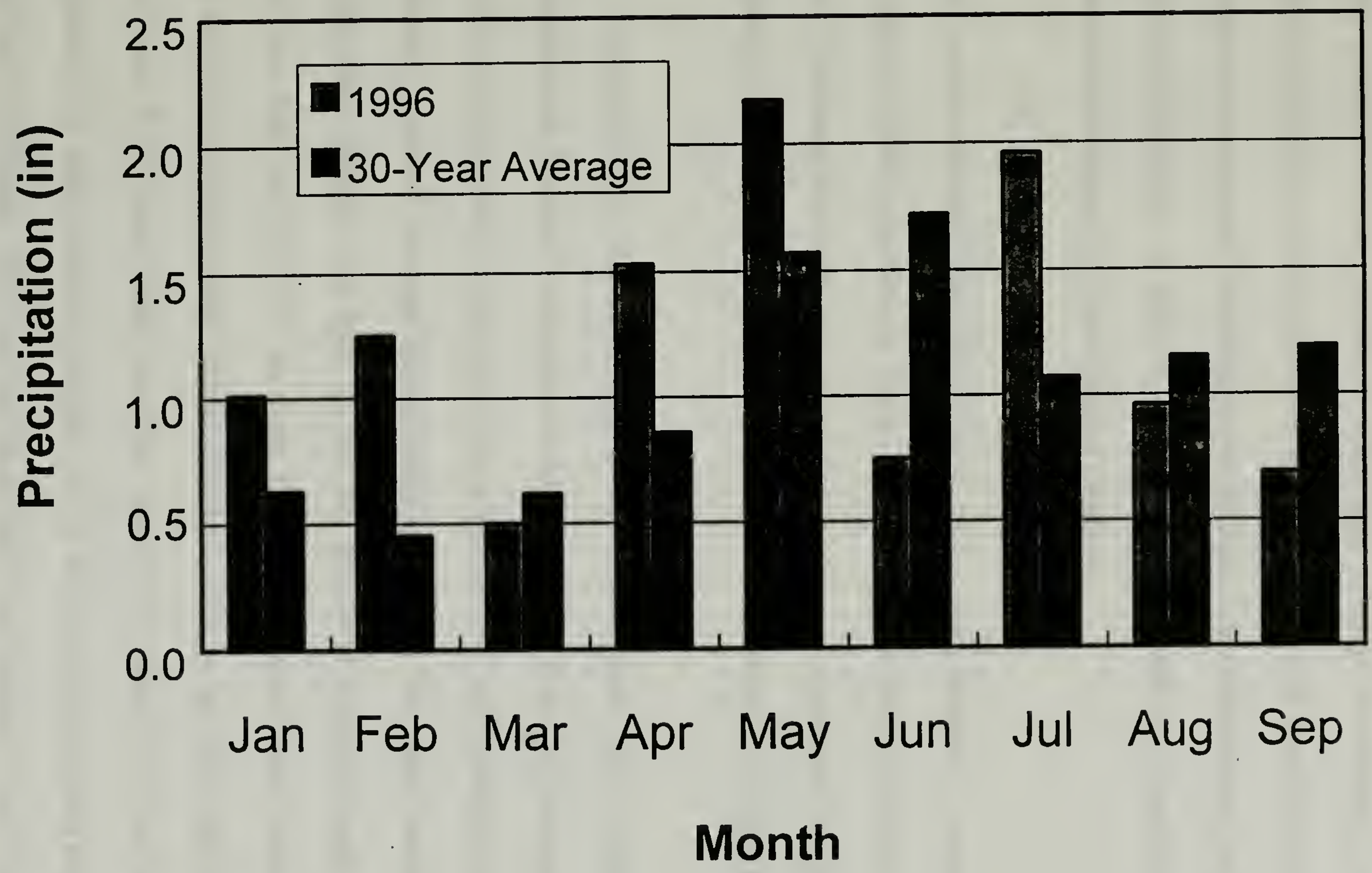


Figure 5. Monthly precipitation, 1996 and 30-year average, Wisdom, Montana. Data from NOAA (1991) and NWS (1996).

In addition to characterizing seasonal trends, water-level data were used to identify areas in the basin where unusually high recharge or discharge occurs. Table 4 lists the wells with the greatest water-level increases from May through mid-July and the greatest water-level declines from July to mid-August. With the exception of M:108251, M:152571, and M:156201, all wells listed are close to surface-water diversions or flood-irrigated meadows.

Water levels in several of the wells listed in table 4 were tracked in conjunction with nearby surface-water flow or stage. The hydrographs shown in figures 6, 7, 8, and 9 generally reinforce the concept that the large ground-water fluctuations at these locations are associated with water use in the diversions or on the fields.

The hydrograph for M:108610 (figure 9) demonstrates this relationship particularly well. The well is located on a ridge about 110 ft west of a large canal and flood-irrigated field; it is approximately a quarter mile from Governor Creek. Following a period of recharge from an early spring thaw, the water level in the well gradually declined until May 12, the day that flood irrigation began. The water level then rose 16.7 ft in six days. For the next seven weeks, the water level remained relatively stable. When irrigation ended on or about July 9, the water level in the well began declining about 0.33 ft/day. By the end of September, the water level had dropped 19.7 ft, and the rate of decline was just beginning to decrease. This slow decline suggests that irrigation return flows in

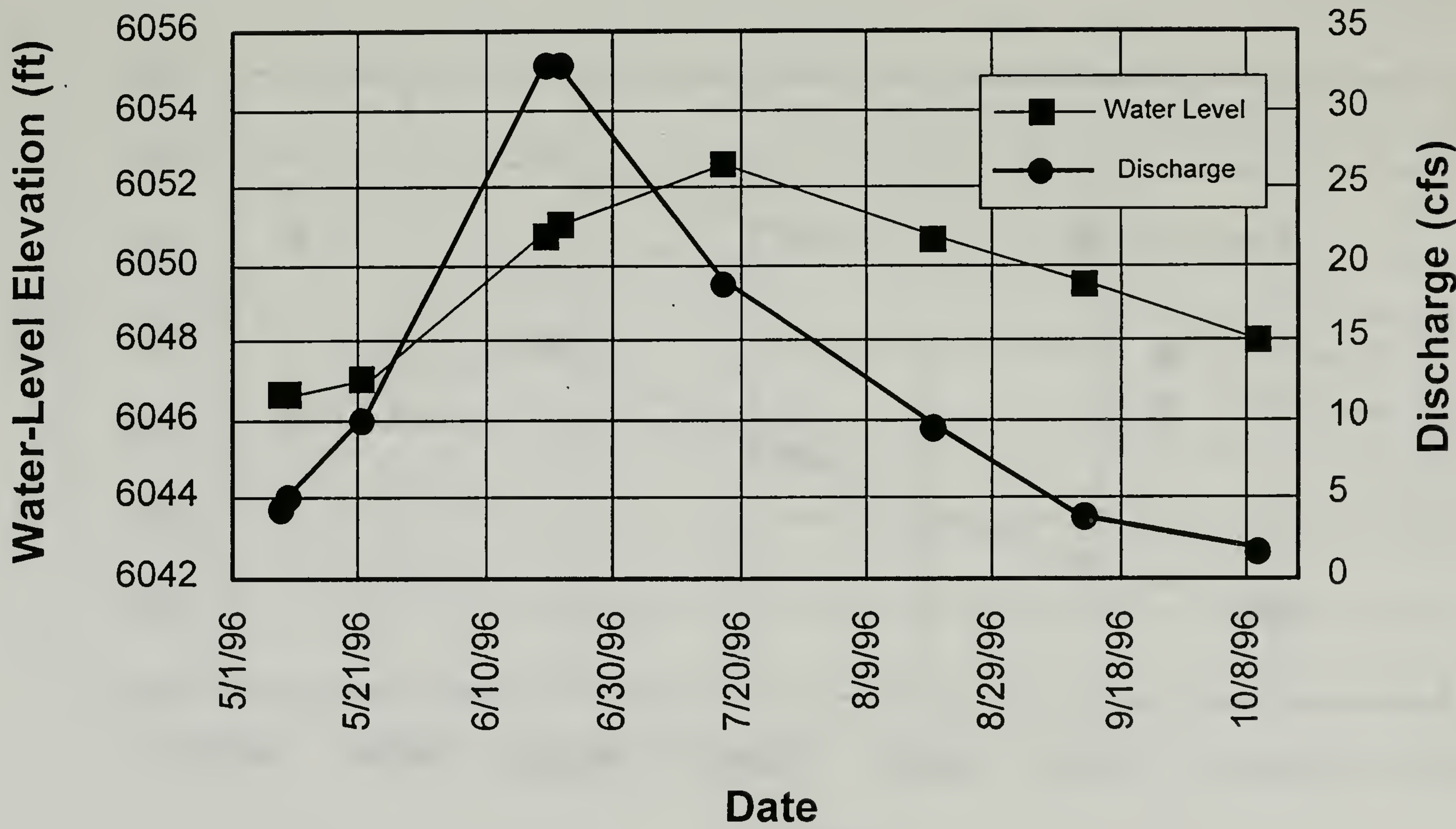


Figure 6. Water level of well M:153310 and discharge of Spokane ditch at SD09, May–October, 1996.

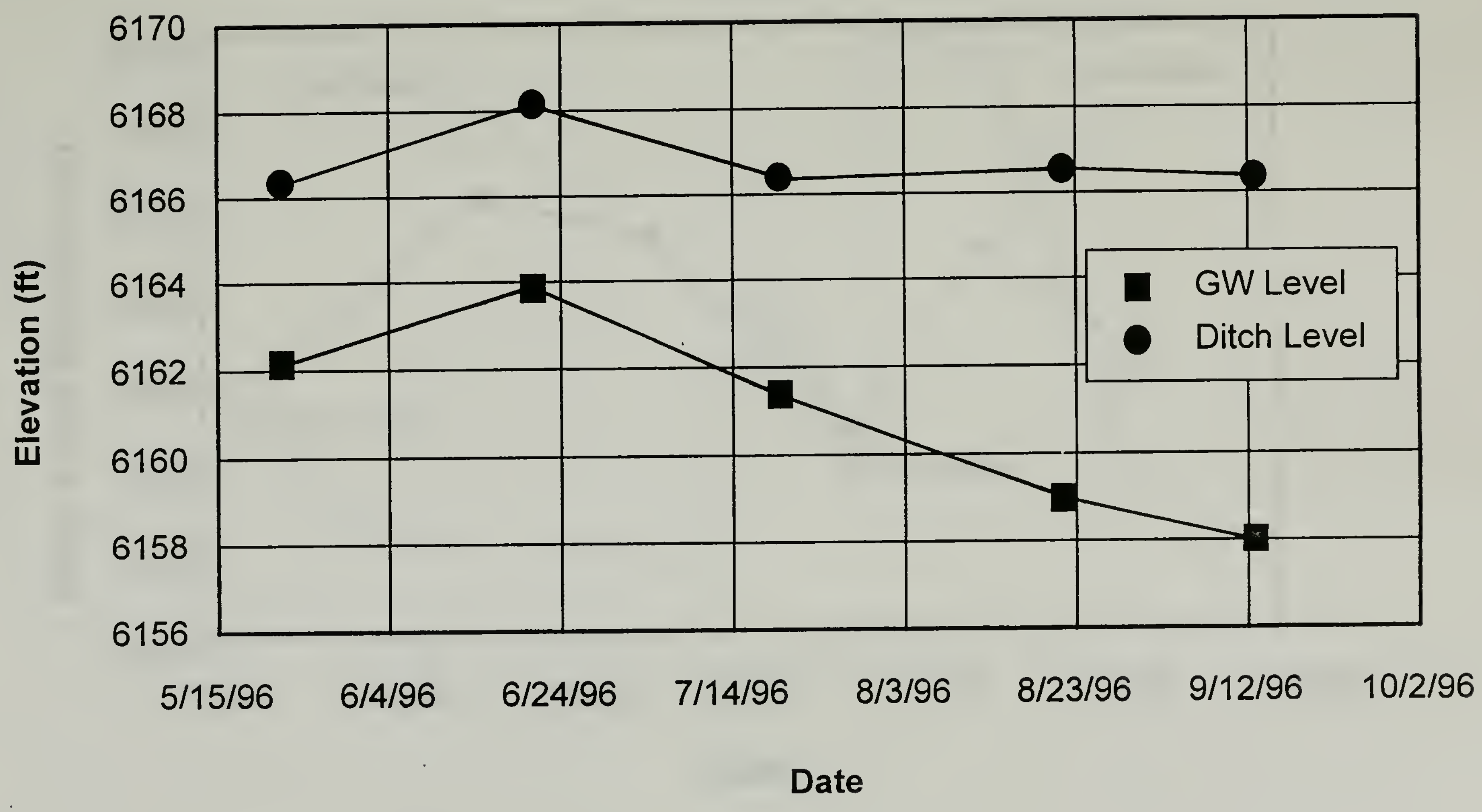


Figure 7. Water level of well M:156238 and level of Turner ditch at TU05, May–September, 1996.

Figure 8. Water level in well M:145341 and use of Nelson ditch at JN01, May–October, 1996.

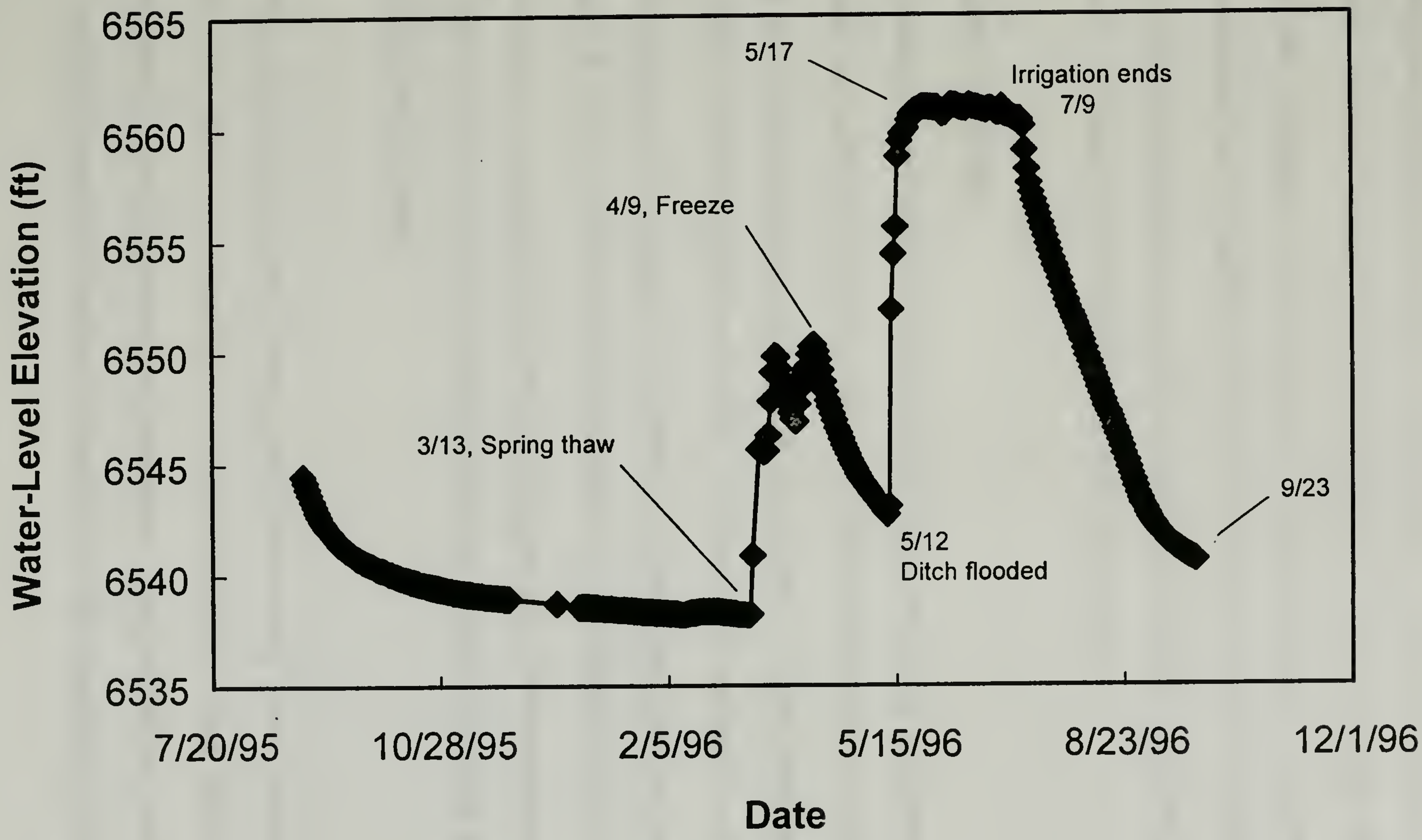
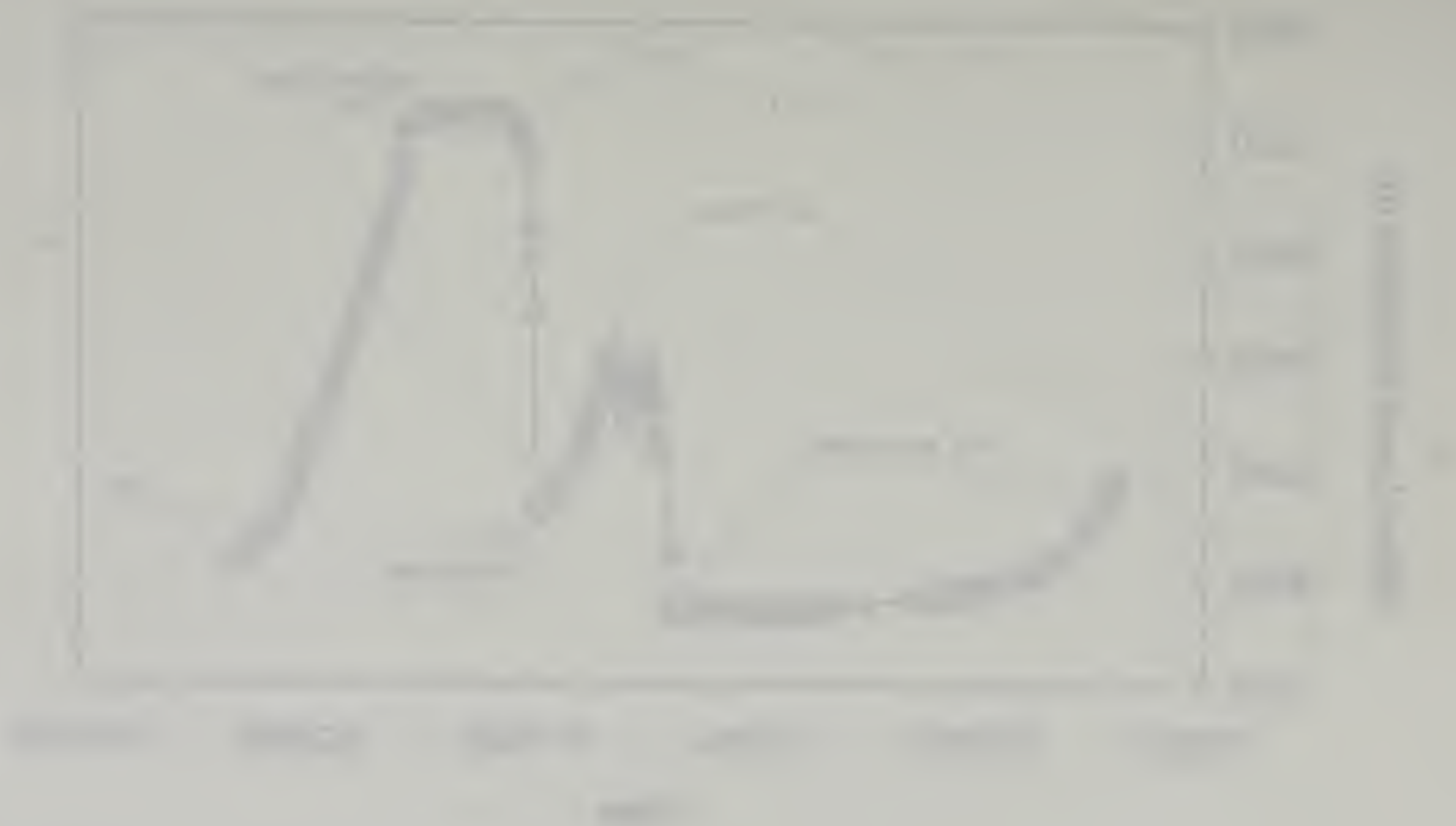


Figure 9. Water level of well M:108610 and use of Strodtman ditch at ST01, August 1995–September 1996.



this portion of the Big Hole basin may contribute to higher than normal ground-water discharge to the surface-water system for more than two months following the end of irrigation. The timing of return flows depends on many variables, including aquifer permeability, soil moisture, depth to water table, and distance to ground-water discharge areas; hence, return flows elsewhere in the basin may occur over longer or shorter periods than the above example.

SURFACE WATER

Diversion Flow Loss: Flow measurements were made along 18 surface-water diversions during the summers of 1995 and 1996 to evaluate rates of water loss or gain. Most flow measurements were made using a current meter. At a few locations, Parshall flumes are present, so flows were calculated from flume geometry and stream stage. The locations of the measuring points are shown on plate 2, and a summary of the data obtained are presented in table 5. On the average, the diversions lost 0.6 cfs/mile (270 gpm/mile). The maximum loss rate recorded was 3.9 cfs/mile (1,750 gpm/mile); the maximum gain rate was 1.3 cfs/mile (600 gpm/mile).

Flow data also were obtained from gaging stations along a four-mile section of the Ruby ditch south of the Big Hole National Battlefield. These stations were maintained by the U.S. Bureau of Reclamation (USBR) during the 1994, 1995, and 1996 summer field seasons. The average loss rate calculated from the 1994

Table 5: Summary of flow loss/gain rates for irrigation ditches in the upper Big Hole basin.

Ditch Reach	Upstream Location	Downstream Location	Date	Upstream (cfs)	Downstream (cfs)	Loss or Gain (cfs)	Distance (miles)	Rate of Loss or Gain cfs/mile	Average Loss or Gain (cfs/mile)
B02/03 to B01	05S 15W 06 BCCB	04S 15W 29 BDBD	7/18/95	39.0	40.2	1.20	2.72	0.44	0.44
B04 to B05	05S 16W 01 CDAA	04S 15W 31 CBBB	8/20/96	6.51	6.06	-0.45	1.48	-0.30	-0.30
BH01 to BH02	03S 17W 27 CBAB	03S 17W 22 ADBD	9/20/95	4.14	4.71	0.57	1.51	0.38	
BH01 to BH02	03S 17W 27 CBAB	03S 17W 22 ADBD	6/19/96	16.5	12.7	-3.8	1.51	-2.52	
BH01 to BH02	03S 17W 27 CBAB	03S 17W 22 ADBD	7/17/96	9.03	10.1	1.07	1.51	0.71	
BH01 to BH02	03S 17W 27 CBAB	03S 17W 22 ADBD	8/19/96	4.30	5.35	1.05	1.51	0.70	
BH01 to BH02	03S 17W 27 CBAB	03S 17W 22 ADBD	9/12/96	3.69	3.39	-0.30	1.51	-0.20	-0.19
CL01 to CL05	02S 16W 02 ABBB	02S 16W 01 BBAB	8/18/95	18.4	15.2	-3.20	0.94	-3.40	-3.4
CL03 to CL04	02S 16W 01 BBAD	01S 16W 36 DCBD	8/18/95	6.90	6.25	-0.65	0.46	-1.41	-1.41
FH01 to FH02	03S 17W 13 BAAA	03S 17W 12 DDCC	7/21/95	0.44	0.74	0.30	0.31	0.97	
FH10 to FH02	03S 17W 13 BAAC	03S 17W 12 DDCC	8/16/95	0.55	0.57	0.02	0.44	0.05	
FH10 to FH02	03S 17W 13 BAAC	03S 17W 12 DDCC	9/19/95	0.28	0.34	0.06	0.44	0.14	0.38
FH03 to FH04	03S 17W 13 AACB	03S 16W 07 CDBA	7/21/95	1.65	1.97	0.32	0.73	0.44	
FH03 to FH04	03S 17W 13 AACB	03S 16W 07 CDBA	8/16/95	1.34	1.25	-0.09	0.73	-0.12	
FH03 to FH04	03S 17W 13 AACB	03S 16W 07 CDBA	9/19/95	1.07	1.19	0.12	0.73	0.16	
FH03 to FH04	03S 17W 13 AACB	03S 16W 07 CDBA	6/19/96	0.67	0.68	0.01	0.73	0.01	
FH03 to FH04	03S 17W 13 AACB	03S 16W 07 CDBA	7/17/96	5.68	5.55	-0.13	0.73	-0.18	0.06
FH05 to FH08	03S 17W 12 ABDA	03S 16W 07 CACA	7/21/95	9.94	8.91	-1.03	1.14	-0.90	
FH09 to FH08	03S 17W 12 ABAA	03S 16W 07 CACA	8/16/95	2.12	2.90	0.78	1.48	0.53	
FH09 to FH08	03S 17W 12 ABAA	03S 16W 07 CACA	9/19/95	1.35	1.50	0.15	1.48	0.10	-0.09
H01 to H06	05S 15W 09 AACB	05S 15W 04 ACDA	7/18/95	1.35	0.82	-0.53	1.02	-0.52	-0.52
HT01 to HT04	04S 15W 21 BDCC	04S 15W 03 CDAC	9/21/95	2.85	2.12	-0.73	3.38	-0.22	
HT03 to HT05	04S 15W 16 DBCB	04S 15W 03 BDDD	7/19/96	0.11	0.25	0.14	2.75	0.05	
HT01 to HT06	04S 15W 21 BDCC	04S 15W 03 BDDD	8/20/96	2.35	2.45	0.10	3.78	0.03	-0.05
JD01 to JD03	05S 16W 36 BCAD	06S 16W 01 BCAB	7/19/95	11.7	10.3	-1.4	1.32	-1.09	
JD01 to JD03	05S 16W 36 BCAD	06S 16W 01 BCAB	6/20/96	14.7	11.0	-3.74	1.32	-2.83	-1.96
JD02 to JD06	05S 16W 36 ACCB	05S 15W 31 CDCC	7/19/95	3.32	2.06	-1.25	1.26	-0.99	
JD02 to JD06	05S 16W 36 ACCB	06S 15W 31 CDCC	6/20/96	3.59	2.02	-1.57	1.26	-1.26	-1.12
MC01 to MC04	03S15W16CDDD	03S15W10BACC	7/18/96	1.78	1.40	-0.38	2.14	-0.18	-0.18
NL01 to NL04	04S 16W 02 BADC	03S 16W 35 ADAA	8/17/95	2.64	2.00	-0.64	1.35	-0.47	
NL01 to NL05	04S 16W 02 BADC	03S16W35BBBC	7/19/96	0.13	0.16	0.03	1.58	0.02	
NL01 to NL05/TU04	04S 16W 02 BADC	03S16W35BBBC	8/21/96	0.92	0.71	-0.22	1.58	-0.14	-0.20
SD01 to SD02	02S 16W 36 DBCD	02S 16W 36 BDCB	8/15/95	9.73	7.50	-2.23	0.57	-3.91	
SD01 to SD02	02S 16W 36 DBCD	02S 16W 36 BDCB	9/18/95	18.7	17.2	-1.50	0.57	-2.63	-3.27
SD04 to SD05	02S 16W 36 BDBC	02S 15W 30 CDAC	8/15/95	9.07	8.53	-0.54	2.35	-0.23	
SD04 to SD05	02S 16W 36 BDBC	02S 15W 30 CDAC	9/18/95	1.30	1.20	-0.10	2.35	-0.04	-0.14
SD06 to SD07	02S 16W 36 BDBC	02S 16W 25 CAAB	8/15/95	1.18	1.49	0.31	0.90	0.34	
SD06 to SD07	02S 16W 36 BDBC	02S 16W 25 CAAB	9/18/95	20.1	21.3	1.20	0.90	1.33	
SD06 to SD08	02S 16W 36 BDBC	02S16W25BDDB	8/21/96	7.55	8.53	0.98	1.02	0.96	
SD08 to SD09	02S16W25BDDB	02S16W24ADBC	5/9/96	5.00	5.11	0.11	1.20	0.09	0.68
TU01 to TU04	04S 16W 02 ABBD	03S 16W 25 CCDA	8/17/95	4.35	4.73	0.38	1.73	0.22	
TU01 to TU04	04S 16W 02 ABBD	03S 16W 25 CCDA	9/20/95	1.96	1.86	-0.10	1.73	-0.06	0.08
							Average:	-0.38	-0.62
							StDev:	1.16	1.18
							Max:	1.33	0.68
							Min:	-3.91	-3.40

data was 0.8 cfs/mile (370 gpm/mile). The maximum loss rate was 5.1 cfs/mile (2,300 gpm/mile) and occurred in the early spring when flow in the ditch was greatest. In August, when flow in the ditch was lowest, an average flow gain of 0.2 cfs/mile was observed.

At several locations where wells are located close to ditches, leakage estimates were obtained using the Darcy equation:

$$Q=KIA \qquad (1)$$

where Q is flow, K is hydraulic conductivity, I is hydraulic gradient, and A is area. For the calculations, K was taken to be 1.1 ft/day, the most reliable estimate obtained from the aquifer tests during this study (see table 1); I was estimated using the difference between the water level in the ditch and that in the nearby well and dividing by the well depth; A was determined by multiplying estimated ditch width by 5,280 ft (1 mile). Calculated losses ranged from 0.1 to 0.3 cfs/mile (table 6). Although these values fall slightly below the average losses measured in the field, the agreement is still good. Increasing K by a factor of three to four would result in close agreement between the calculated and field values.

Relationship between Diversion Flow Rate and Loss: In addition to estimating the average, maximum, and minumum flow losses, the 1994 data

Table 6: Estimates of flow loss from select ditches based on Darcy's equation.

Ditch	Well	Location	Maximum Observed Gradient (ft/ft)	Ditch Width* (ft)	Width x 5280 ft (ft^2)	Hydraulic Conductivity (ft/day)	Flow Loss (cfs/mile)
JN01	M:145341	02S15W32ABAB	0.22	10	52800	1.1	0.15
SD09	M:153310	02S16W24ADBC	0.33	15	79200	1.1	0.33
ST01	M:108610	05S15W36CABD	0.12	15	79200	1.1	0.12
TU05	M:156238	03S16W26ADAA	0.30	10	52800	1.1	0.20

* Width visually estimated.

from the Ruby ditch were analyzed to determine if a relationship exists between flow rate and loss from the ditch. Figure 10, a scatter plot of flow loss versus flow rate at the ditch's head gate, reveals a nearly linear relationship. A linear-regression analysis yields the following predictive equation for the loss rate:

$$R = 0.14Q - 0.74 \qquad (2)$$

where R is the loss rate (cfs/mile), and Q is the upstream flow rate (cfs).

A similar analysis was performed on the flow data collected from the 18 ditches monitored by MBMG (see table 5 and figure 11). The large scatter evident in the data may reflect the variable hydrogeology across the study area. However, after three extraneous points are removed from the data set, a linear regression yields an equation remarkably similar to that for the Ruby ditch:

$$R = 0.17Q - 0.39 \qquad (3)$$

Water loss from an unlined ditch typically results from ET and/or leakage through the bed materials into the ground-water system. For the Big Hole basin, the ET component of R appears to be minor. Figure 12, a plot of R from the Ruby ditch vs. time (one irrigation seaon), shows that R tends to be greatest during late May and early June when ET is just beginning to increase. During July and August,

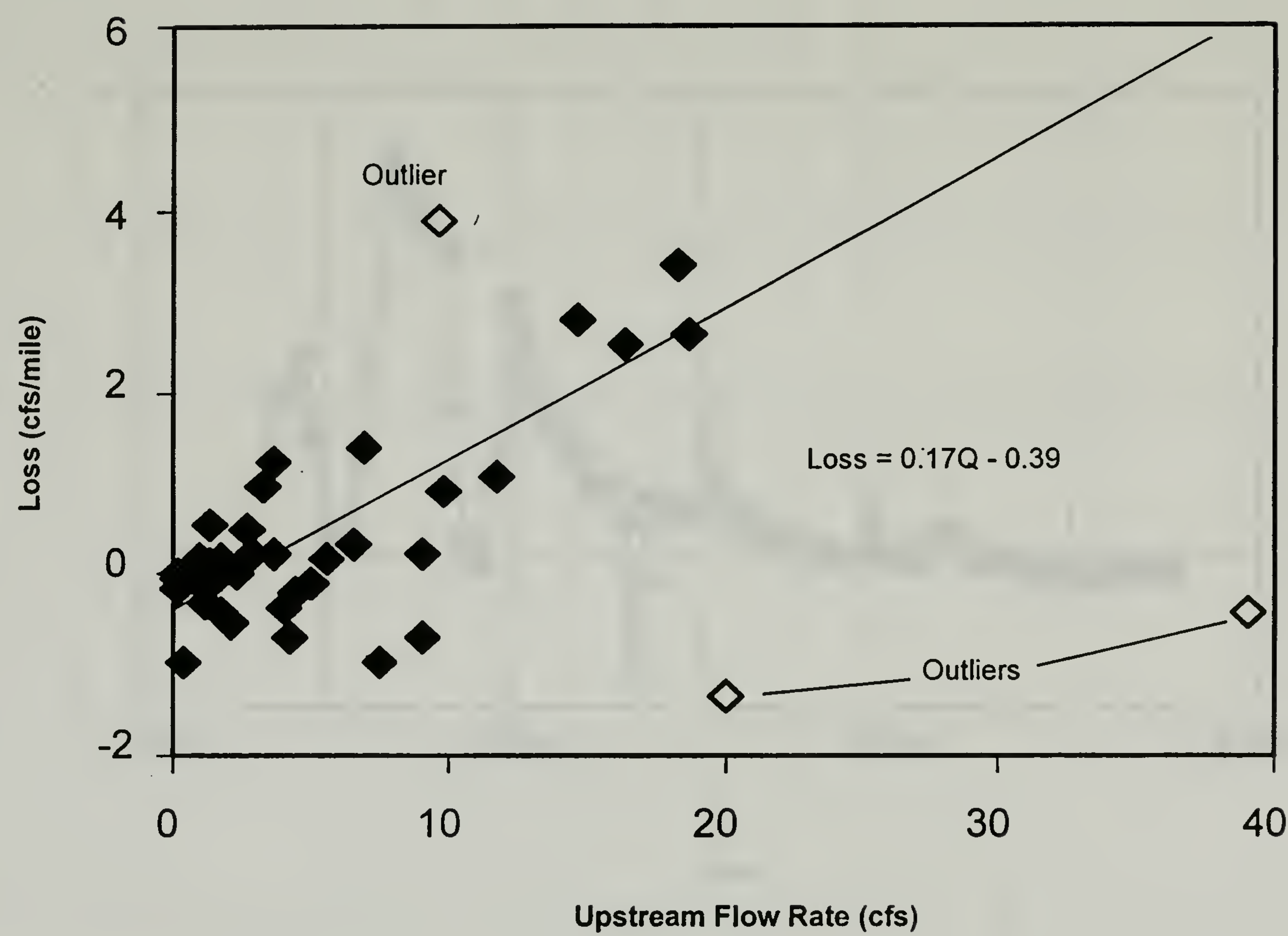
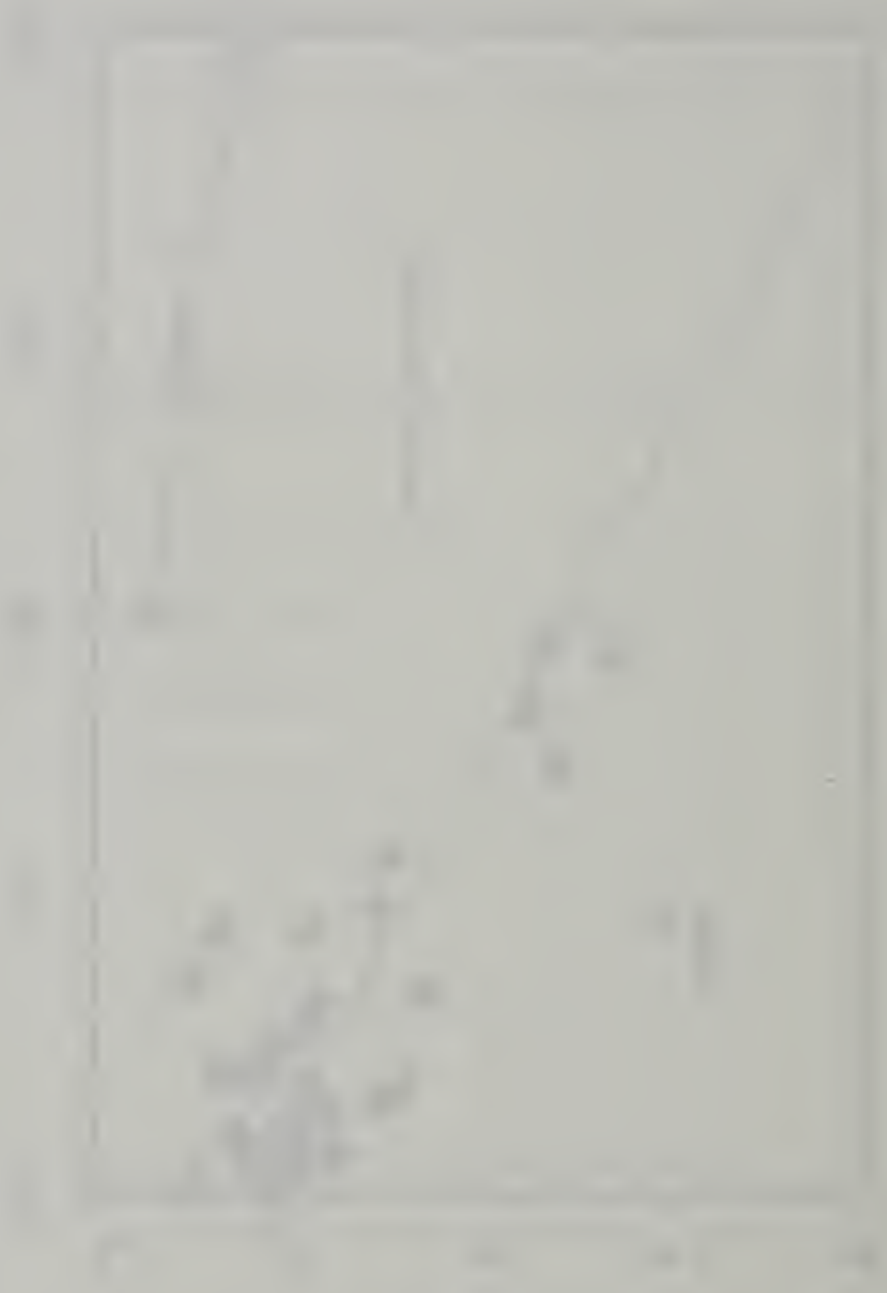


Figure 11. Scatter plot of flow loss vs. flow rate. Data gathered from 18 ditches.



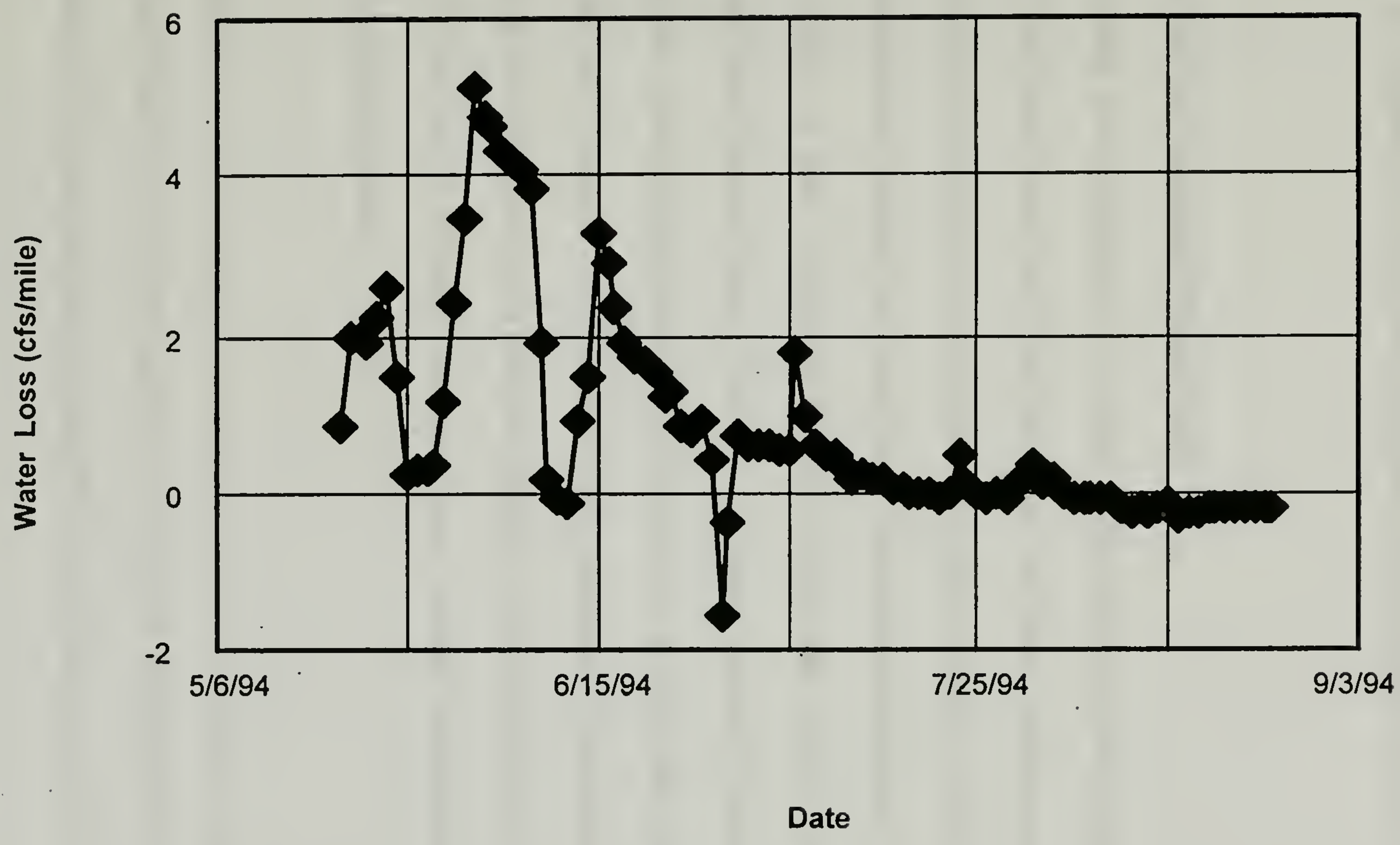


Figure 12. Plot of rate of water loss vs. time, Ruby ditch, 1994. Data from the U.S. Bureau of Reclamation.

when ET should be close to maximum, the data show that the ditch is actually gaining water. Because R appears to represent leakage, equations 2 and 3 are valuable for modeling aquifer recharge from surface-water diversions in the basin.

EVALUATION OF GW/SW INTERACTIONS

Return Flows from Irrigation: The data gathered during this investigation indicate that return flows from flood irrigation and stock watering contribute significantly to the recharge of the basin's near-surface aquifer. As discussed in the previous section, average loss rates from diversions are between 0.5 and 1 cfs/mile. Much of this water enters the ground-water system, where it presumably helps maintain higher than normal discharge rates to the surface-water system. Data collected from well M:108610 on a ridge that is about a quarter mile from Governor Creek suggest that discharge to the surface-water system may be affected for more than two months. At other locations, the effect is likely to be shorter or longer, depending on aquifer characteristics and distance to discharge areas.

The magnitude of the increase in ground-water discharge is another unknown. A higher water table during the late summer may result in increased ET losses. If the increase in ET is great enough, the benefit of return flows may be lost.

Stock Well Use: Increased use of stock wells in the upper Big Hole basin is unlikely to have a detrimental impact on ground-water discharge to surface drainages during the summer. A distance-drawdown curve calculated with transmissivity equal to 500 ft^2/day (approximate average for the near-surface aquifer, Levings 1986) shows that a well pumped at 10 gpm continuously for 60 days only affects the aquifer within several hundred feet of the well (figure 13). Therefore, if such a well is placed close to a ground-water discharge area along a surface drainage, only a small portion of the discharge area is likely to be influenced by the well.

CONCLUSIONS

A gw/sw water interaction study was conducted in the upper Big Hole basin of southwest Montana from July 1995 through October 1996. The purpose of the study was to address concerns about possible changes in surface and ground-water management. Objectives included obtaining aquifer characteristic data, estimating water loss along surface-water diversions, and gathering other information to further the understanding of the basin's hydrology.

Most wells in the basin are completed in Tertiary and Quaternary sediment. Aquifer tests at five locations yielded hydraulic conductivity estimates ranging from 0.02 to 1.1 ft/day, reflecting the large degree of variability within hydrologic

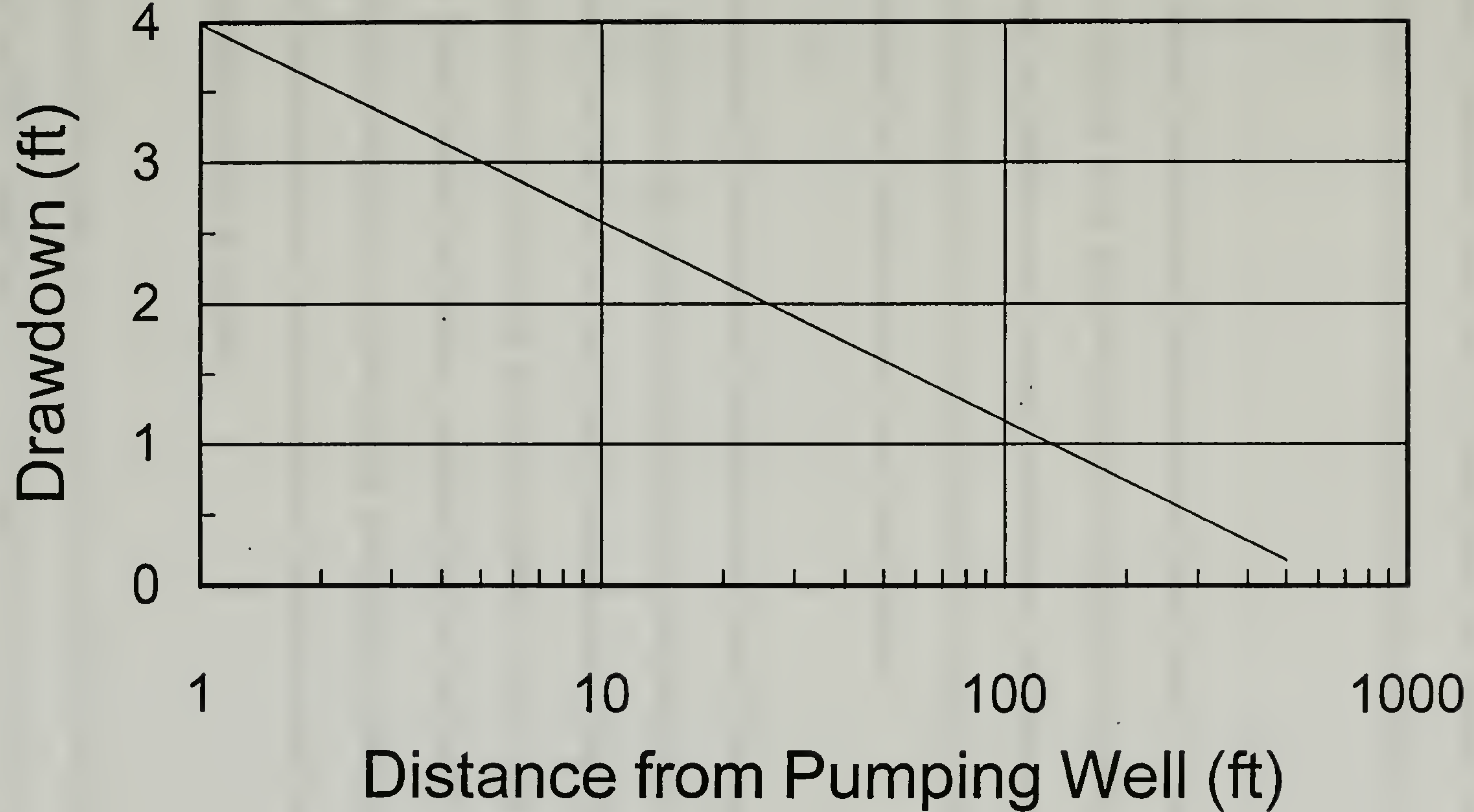


Figure 13. Distance-drawdown curve for a typical well in the upper Big Hole basin. Transmissivity is 500 ft^2/day, pumping rate is 10 gpm, and time is 60 days.

formations. A potentiometric surface map (plate 1) shows that ground-water flow in the basin is generally toward the Big Hole River, with another component of flow northward. At the north end of the basin, all ground-water flow is toward the river.

On the average, ground-water levels across the basin rose 2.3 ft between mid-May and mid-June 1996. Between June and July, water levels declined about 0.3 ft. After July, levels dropped sharply, approaching those observed in May. At a number of locations, larger than average water-level rises and declines were associated with flood irrigation and/or use of nearby ditches.

Flow losses along 18 surface-water diversions were found to average about 0.6 cfs/mile. The Ruby ditch, equipped with continuous recorders by the USBR, had an average loss of 0.8 cfs/mile (period May–August 1994). Flow losses calculated for four ditches using the Darcy equation ranged from 0.1 to 0.3 cfs/mile. Scatter plots of flow loss vs. upstream flow rate for the 18 ditches and the Ruby ditch were found to have similar linear trends. Predictive flow-loss equations were derived and will be valuable for modeling aquifer recharge from surface-water diversions in the basin.

Flow loss and water-level data indicate that flood irrigation and surface-water diversion contribute significantly to the recharge of the basin's near-surface

aquifer. At one well location (M:108610), ground-water levels rose 17 ft at the beginning of the 1996 irrigation season. Enhanced recharge such as this probably improves ground-water discharge to the surface-water system for a period of time following the irrigation season. Data collected during the study suggest that the effect could be as long as two months or as short as several days. Distance-drawdown calculations indicate that increased use of stock wells is unlikely to have a detrimental impact on ground-water discharge to the basin's surface-water system.

RECOMMENDATIONS FOR FUTURE WORK

To adequately characterize gw/sw interactions and the effects of return flows in the upper Big Hole basin, several data gaps need to be filled. First, additional hydraulic conductivity and transmissivity data are needed to characterize the basin aquifer's flow rates and timing of return flows. Secondly, additional gaging stations are needed along the main stem of the river and select tributaries to relate ground-water fluctuations and return flows to stream discharge rates.

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APPENDIX A:

WELLS INVENTORIED IN THE UPPER BIG HOLE BASIN, 1996,

LIST OF WELLS BY SORTED BY LEGAL DESCRIPTION,

AND

EXPLANATION OF TOWNSHIP-RANGE-SECTION-TRACT

Appendix A: Well inventory data sorted by M:Number

M:Number*	Legal Description (Township, Range, Section, Tract)	Latitude (min, deg, sec)	Longitude (min, deg, sec)	USGS 7.5 min Quad	Altitude of Land Surface (ft)	Measuring Point Elevation (ft)	Depth to Water (ft)	Water Level Elevation (ft)	Date of Measurement	Depth of Well (ft)	Well Use
8977	01S14W18ACDD	454459	1132214	PROPOSAL ROCK	5920	5920.0	13	5907.0	5/9/96	52	DOMESTIC
8982	01S16W10CBCB	454534	1133423	MUSSIGBROD LAKE	6325	6325.0	6.9	6318.1	5/21/96	–	DOMESTIC
9009	03S16W09BAAD01	453537	1133505	HIGHLAND RANCH	6197	6198.0	8.20	6189.8	9/12/96	40	DOMESTIC
9010	03S16W36ACDA	453151	1133059	HIGHLAND RANCH	6176	6176.0	2.5	6173.5	5/9/96	35	STOCK
9037	05S15W23CABA	452227	1132520	FOX GULCH	6425	6426.6	5.5	6421.1	5/23/96	140	DOMESTIC
9043	05S15W26ADAD	452215	1132433	JACKSON	6470	6470.5	9.91	6460.6	5/23/96	160	IRRIGATION
48849	01N14W15DDDD	454946	1131858	PINE HILL	6030	6030.0	7	6023.0	5/21/96	36	DOMESTIC
48852	01N15W34DDAA	454719	1132629	PINTLER LAKE	6130	6130.6	34.46	6096.1	5/21/96	49	IRRIGATION
107193	01S14W18CDAB01	454441	1132237	MUD LAKE	5941	ND	40	5901.0 E	–	65	DOMESTIC
107198	01S15W04DDCB01	454620	1132707	PINTLER LAKE	6070	ND	28	6042.0 E	–	86	STOCK
107199	01S15W05BCBA01	454653	1132911	PINTLER LAKE	6150	ND	110	6040.0 E	–	160	STOCK
107203	01S15W09CDDA01	454530	1132731	PINTLER LAKE	6013	6013.4	10.16	6003.2	5/21/96	39	DOMESTIC
107204	01S15W20DDCA01	454343	1132818	MUD LAKE	6006	ND	22	5984.0 E	–	69	STOCK
107205	01S15W35BCAC	454230	1132526	MUD LAKE	5970	5970.0	12.02	5958.0	5/9/96	–	STOCK
107496	02S15W32AABB	453731	1132827	MUD LAKE	6051	6052.0	16.06	6035.9	5/8/96	57	DOMESTIC
107542	02S15W34BACD	453720	1132630	WISDOM	6043	ND	NA	–	–	50	DOMESTIC
107678	03S15W04ADDA01	453617	1132658	WISDOM	6062	6064.4	6.13	6058.2	7/19/96	42	DOMESTIC
107679	03S15W04DDBA	453559	1132709	WISDOM	6170	6079.8	5.56	6074.2	5/8/96	36	STOCK
107681	03S15W16DCCD	453403	1132726	WISDOM	6140	6141.9	28.4	6113.5	5/8/96	87	STOCK
107684	03S15W20CDAC	453318	1132855	WISDOM	6138	6139.8	0.36	6139.4 F	5/8/96	33	STOCK
107688	03S15W21DBDC02	453323	1132720	WISDOM	6150	6150.3	8.31	6142.0	6/21/96	81	STOCK
107689	03S15W21DBDC01	453323	1132720	WISDOM	6150	6151.9	10.88	6141.0	5/8/96	33	STOCK
107699	03S16W31DDDD01	453122	1133658	HIGHLAND RANCH	6510	ND	142	6368.0 E	–	166	DOMESTIC
107700	03S16W31DDDD02	453124	1133700	HIGHLAND RANCH	6510	ND	125	6385.0 E	–	190	DOMESTIC
108245	05S15W05BBAD	452600	1132906	FOX GULCH	6360	6362.0	48.17	6313.8	5/22/96	105	STOCK
108246	04S15W32DDCD	452601	1132820	FOX GULCH	6325	6327.1	7.60	6319.5	5/22/96	46	STOCK
108247	04S16W03BCCC	453051	1133424	HIGHLAND RANCH	6362	6363.2	48.95	6314.3	5/22/96	110	IRRIGATION
108251	04S16W06DAAD	453045	1133656	HIGHLAND RANCH	6525	6526.4	98.32	6428.1	5/22/96	110	DOMESTIC
108254	04S16W36DDDA	452606	1133040	AJAX RANCH	6425	6426.6	3.48	6423.1	5/22/96	58	STOCK
108583	05S15W03BDCB	452541	1132639	FOX GULCH	6319	ND	0	6319.0 F	–	66	DOMESTIC
108585	05S15W05BDAD	452544	1132849	FOX GULCH	6365	6366.3	25.58	6340.7	5/22/96	110	DOMESTIC
108590	05S15W10DCDA	452421	1132605	FOX GULCH	6400	6401.0	18.85	6382.2	5/23/96	75	DOMESTIC
108593	05S15W11CCDB01	452422	1132533	FOX GULCH	6450	ND	76	6374.0 E	–	135	DOMESTIC
108595	05S15W17BABA	452416	1132859	FOX GULCH	6428	6429.0	7.34	6421.7	5/22/96	41	DOMESTIC
108606	05S15W27DCAA01	452153	1132607	JACKSON	6460	ND	NA	–	–	50	DOMESTIC
108607	05S15W29ADAD	452214	1132812	JACKSON	6520	6521.0	7.89	6513.1	5/23/96	51	STOCK
108610	05S15W36CABD	452110	1132405	JACKSON	6565	6567.7	6.97	6560.7	5/23/96	36	UNUSED
109103	06S15W07CAAB	451938	1132926	JACKSON	6740	6735.8	130	6605.8 R	6/20/96	220	DOMESTIC
120020	03S15W19CCAA	453318	1133024	HIGHLAND RANCH	6139	ND	8	6131.0 E	–	46	STOCK
120021	03S16W25CCDC01	453214	1133144	HIGHLAND RANCH	6190	ND	10	6180.0 E	–	95	DOMESTIC
121423	06S15W29DADB	451655	1132735	JACKSON	6825	6826.6	57.34	6769.3	5/23/96	237	DOMESTIC

Appendix A: Well inventory data sorted by M:Number

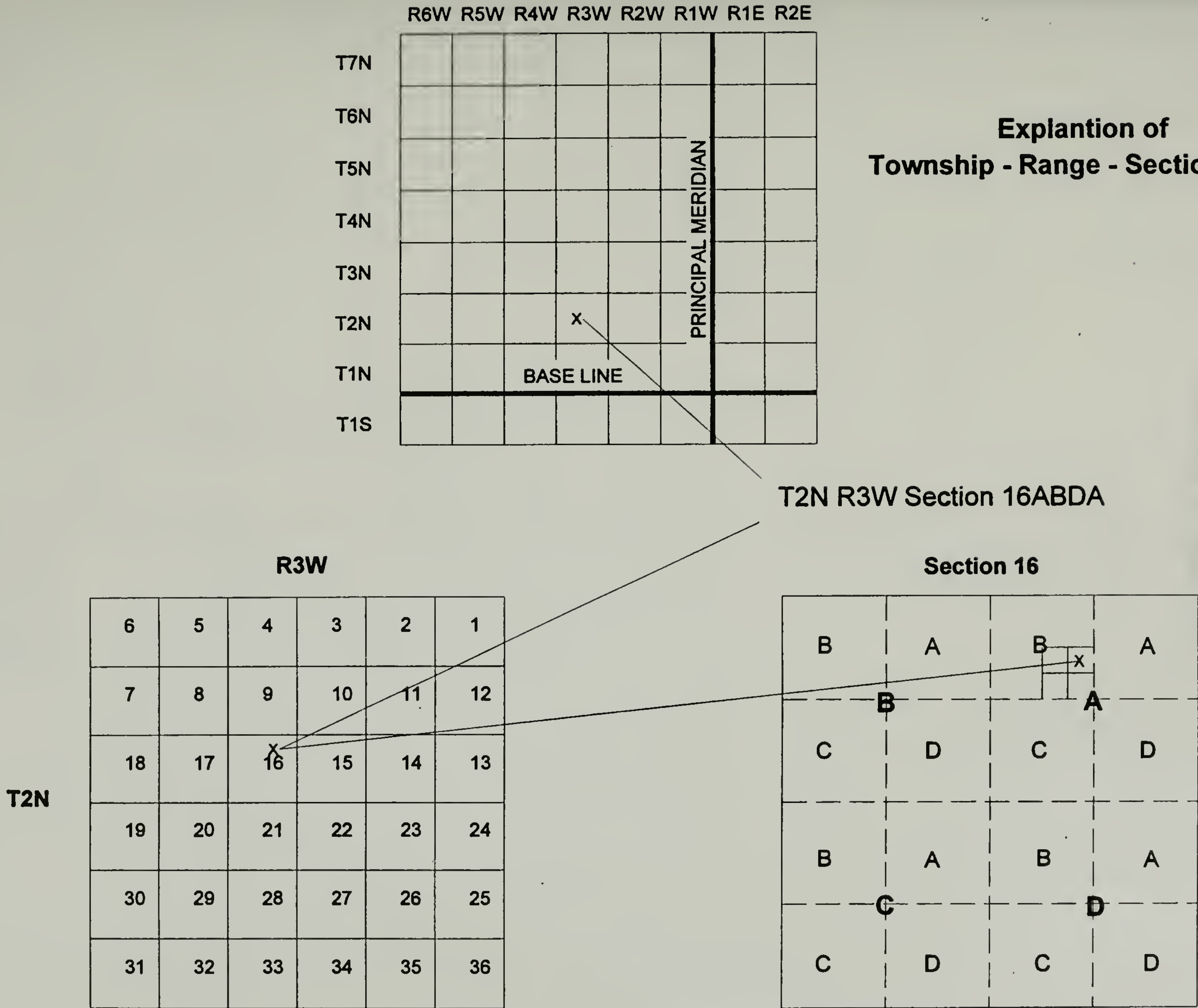
M:Number*	Legal Description (Township, Range, Section, Tract)	Latitude (min, deg, sec)	Longitude (min, deg, sec)	USGS 7.5 min Quad	Altitude of Land Surface (ft)	Measuring Point Elevation (ft)	Depth to Water (ft)	Water Level Elevation (ft)	Date of Measurement	Depth of Well (ft)	Well Use
129086	01S16W34DBDC	454203	1133337	GIBBONS SCHOOL	6070	6071.5	4.80	6066.7	5/21/96	36	DOMESTIC
129151	02S15W34BCCD01	453706	1132647	WISDOM	6045	6046.2	12.20	6034.0	6/21/96	125	DOMESTIC
130113	01S14W19AACB	454421	1132211	PROPOSAL ROCK	6100	ND	23.5	6076.5 E	–	390	DOMESTIC
133218	03S15W01AACC	453625	1132325	WISDOM	6185	6187.2	57.08	6130.1	5/8/96	122	DOMESTIC
141232	04S15W03BDAD	453103	1132620	WISDOM	6215	6216.8	18.94	6197.9	5/22/96	45	STOCK
142700	01S15W33ABDB	454238	1132717	MUD LAKE	5970	5970.0	8.00	5962.0	5/21/96	28	DOMESTIC
143321	01S14W05CADC	454628	1132124	PINE HILL	5920	5920.3	4.78	5915.5	6/19/96	25	DOMESTIC
145332	01S15W02ADDB01	454647	1132427	PINTLER LAKE	6055	6049.0	40.50	6008.5	5/21/96	53	UNUSED
145333	01S15W03BBCD	454655	1132642	PINTLER LAKE	6120	6120.3	46	6074.3 R	5/21/96	109	DOMESTIC
145334	01S15W03BCBA01	454653	1132644	PINTLER LAKE	6122	ND	43	6079.1 E	–	105	DOMESTIC
145340	02S15W29CCAB	453744	1132912	MUD LAKE	6050	6051.1	10.94	6040.2	5/8/96	60	DOMESTIC
145341	02S15W32ABAB	453729	1132835	WISDOM	6055	6055.0	5.44	6049.6	5/8/96	22	STOCK
145348	04S15W05DBCD	453044	1132844	WISDOM	6195	6197.0	1.44	6195.6 F	5/9/96	26	STOCK
145358	06S15W28BBAB	451728	1132718	JACKSON	6764	6766.3	44.44	6721.9	5/23/96	160	DOMESTIC
147061	02S16W35DCAA	453647	1133218	HIGHLAND RANCH	6115	6116.6	5.02	6111.6	5/8/96	32	DOMESTIC
147065	05S15W07CAAC	452437	1133008	AJAX RANCH	6460	6461.5	5.82	6455.7	5/22/96	64	STOCK
148304	04S16W13BBDA01	452922	1133137	AJAX RANCH	6290	ND	10	6280.0 E	–	29	DOMESTIC
151289	01N14W27ABDD	454840	1131913	PINE HILL	5910	ND	0	5910.0 FG	8/29/95	200	UNUSED
152571	03S16W26AACA01	453257	1133212	HIGHLAND RANCH	6195	6197.3	22.42	6174.9	6/20/96	36	STOCK
153310	02S16W24ADBC	453853	1133051	GIBBONS SCHOOL	6076	6078.1	29.34	6046.7	5/8/96	85	STOCK
153311	02S16W25ABAB	453818	1133102	GIBBONS SCHOOL	6077	6078.6	33.46	6043.5	5/8/96	201	STOCK
153312	02S16W07CDAC	454018	1133002	GIBBONS SCHOOL	6060	6062.5	38.87	6023.6	5/20/96	115	STOCK
153313	02S15W32CCCC	453640	1132924	WISDOM	6075	6077.0	15	6062.0 E	10/24/95	185	STOCK
153412	02S15W10DBAB	454034	1132604	MUD LAKE	6020	6022.3	42.52	5979.8	5/9/96	74	STOCK
153413	03S15W02AADD	453626	1132425	WISDOM	6158	6160.0	93.49	6066.5	6/21/96	155	DOMESTIC
156191	03S15W19DDDD	453309	1132923	WISDOM	6137	6139.0	4.97	6134.0	5/22/96	37	DOMESTIC
156192	01S15W02ADAC01	454650	1132428	PINTLER LAKE	6045	6045.0	4.12	6040.9	5/21/96	9	DOMESTIC
156193	01S15W29CDAC	454255	1132850	MUD LAKE	6000	6000.6	15.08	5985.5	5/21/96	38	STOCK
156194	01S16W21ADCC01	454400	1133447	GIBBONS SCHOOL	6180	6180.0	0	6180.0 F	5/21/96	6	UNUSED
156195	01S16W21ADCC02	454401	1133445	GIBBONS SCHOOL	6185	6182.0	1.8	6180.2	5/21/96	9	DOMESTIC
156197	01S16W32ADCA	454218	1133555	GIBBONS SCHOOL	6125	6126.6	6.98	6119.6	5/21/96	28	DOMESTIC
156198	02S15W22ACBC	453858	1132614	MUD LAKE	6060	6061.0	95.3	5965.7	5/9/96	183	DOMESTIC
156200	02S15W28CDCC	453733	1132718	MUD LAKE	6041	6042.2	6.56	6035.6	5/8/96	10	UNUSED
156201	02S15W29CCAB02	453744	1132912	MUD LAKE	6050	6050.0	6.6	6043.4	5/8/96	10	UNUSED
156202	02S15W30DBAA	453757	1132944	MUD LAKE	6050	6051.3	10.42	6040.9	5/8/96	44	DOMESTIC
156203	02S15W30DBAC01	453755	1132949	MUD LAKE	6050	6051.2	7.98	6043.2	5/8/96	31	DOMESTIC
156205	02S15W34BCBA	453714	1132648	WISDOM	6050	6051.3	18.4	6032.9	5/9/96	53	DOMESTIC
156206	02S15W35DACB	453657	1132439	WISDOM	6165	6166.5	96.21	6070.3	6/21/96	125	DOMESTIC
156209	03S15W01BABA	453634	1132357	WISDOM	6165	6166.8	87.58	6079.2	5/8/96	122	DOMESTIC
156210	03S15W01DADA	453605	1132312	WISDOM	6165	6166.3	24.9	6141.4	5/8/96	60	DOMESTIC
156211	03S15W20ABAB	453400	1132834	WISDOM	6140	6141.5	21.2	6120.3	5/8/96	123	DOMESTIC

Appendix A: Well inventory data sorted by M:Number

M:Number*	Legal Description (Township, Range, Section, Tract)	Latitude (min, deg, sec)	Longitude (min, deg, sec)	USGS 7.5 min Quad	Altitude of Land Surface (ft)	Measuring Point Elevation (ft)	Depth to Water (ft)	Water Level Elevation (ft)	Date of Measurement	Depth of Well (ft)	Well Use
156212	03S15W31DBAA	453148	1132949	WISDOM	6170	6170.5	1.5	6169.0	5/9/96	25	DOMESTIC
156215	04S15W03BCCC	453056	1132654	WISDOM	6209	6212.0	4.15	6207.9	5/22/96	70	STOCK
156216	04S15W10AAAA	453027	1132541	WISDOM	6320	6323.2	98.27	6224.9	5/22/96	162	STOCK
156217	04S15W11BBBC	453025	1132536	WISDOM	6340	6341.5	107.24	6234.3	5/22/96	158	STOCK
156218	04S15W16CAAA	452905	1132733	FOX GULCH	6255	6257.6	5.66	6251.9	5/22/96	29	STOCK
156219	04S16W04AABA	453118	1133408	HIGHLAND RANCH	6385	6385.7	27.57	6358.1	5/22/96	77	UNUSED
156220	04S16W04ACCC	453054	1133501	HIGHLAND RANCH	6340	6342.0	0	6342.0 F	7/19/96	–	STOCK
156221	04S16W04BDAD	453058	1133506	HIGHLAND RANCH	6350	6352.0	7.55	6344.5	5/22/96	–	UNUSED
156222	04S16W04DAAD	453047	1133428	HIGHLAND RANCH	6330	6320.0	NA	–	–	–	DOMESTIC
156223	04S16W05BCBC	453059	1133653	HIGHLAND RANCH	6505	6505.8	139.2	6366.6	5/22/96	150	DOMESTIC
156224	04S16W17BABA	452931	1133629	AJAX RANCH	6520	6520.0	3.6	6516.4 F	5/22/96	–	DOMESTIC
156225	05S15W03BCAD	452542	1132642	FOX GULCH	6317	6318.2	3	6315.2	5/22/96	38	DOMESTIC
156226	05S15W10AAAB	452506	1132553	FOX GULCH	6420	6412.0	50.95	6361.1	5/22/96	68	DOMESTIC
156227	05S15W34BCAD	452123	1132641	JACKSON	6500	6500.0	-3	6503.0 F	5/23/96	–	DOMESTIC
156228	05S15W36AAAA	452139	1132316	JACKSON	6534	6535.3	6.2	6529.1	5/23/96	38	DOMESTIC
156229	05S16W02ADCC	452536	1133213	AJAX RANCH	6521	6523.0	4.45	6518.6	5/22/96	10	STOCK
156230	06S15W06ADAA	452044	1132845	JACKSON	6625	6625.0	0	6625.0 F	5/23/96	–	DOMESTIC
156238	03S16W26ADAA	453250	1133159	HIGHLAND RANCH	6170	6170.0	7.82	6162.2	5/22/96	33	STOCK
156863	01S15W03BCBA02	454654	1132645	PINTLER LAKE	6119	ND	NA	–	–	–	DOMESTIC
156864	01S15W03CBAC01	454636	1132640	PINTLER LAKE	6100	ND	NA	–	–	–	STOCK
156865	01N15W35DCDC01	454708	1132534	PINTLER LAKE	6127	ND	NA	–	–	–	UNUSED
156866	02S15W22ACAD01	453858	1132559	MUD LAKE	6080	ND	NA	–	–	–	DOMESTIC
156867	05S15W35AAAA01	452140	1132432	JACKSON	6477	ND	NA	–	–	–	DOMESTIC
156868	04S15W28ACCD01	452721	1132724	FOX GULCH	6340	6340.5	28.55	6312.0	8/20/96	–	UNUSED
156869	03S16W25BBBB01	453302	1133155	HIGHLAND RANCH	6171	ND	NA	–	–	–	DOMESTIC
157395	03S15W01ABAD01	453633	1132327	WISDOM	6182	6184.1	48	6136.0	10/9/96	162	DOMESTIC

Notes:
* Well ID from Ground-Water Information Center
E - Water level from GWIC
F - Flowing well or water level above ground surface
R - Water level recovering at time of measurement
G - Well no longer exists. Grouted to surface
ND - Not determined

Explantion of Township - Range - Section -Tract



APPENDIX B: WELL LOGS

M: 153310

MONTANA BUREAU OF MINES AND GEOLOGY
WELL DATA SHEET

TOWNSHIP 02 N ☐ S ☒ RANGE 16 E ☐ W ☒ SECTION 21 TRACT ADBC SEQUENCE NO. 01

COUNTY BEAVERHEAD CODE ___

Original owner: John Erb

Address: 555 Skyline Dr., Dillon 59725

Owner (1995 yr.): JOHN ERB

Resident (if not owner): SPOKANE RANCH

Addition (if in subdivision): ______ Block: ____ Lot: ____ Other: ______

USGS 7.5' map: GIBBONS SCHOOL, MONT

Lat. 45° 38' 53" N; Lon 113° 30' 52" W

Altitude of Land Surface (L.S.) @ well: ______ Ft.

REPORTED DATA

Total depth of well below L.S.: 85 Ft.

Pumping water level below L.S.: ____ Ft.

Static water level below* L.S.: 22.6 Ft.

Yield in gallons per minute: 20

How tested: DRILLER ESTIMATE hours: ___

If flowing, shut-in pressure in PSI: ___

CASING

From (Ft.)	To (Ft.)	Dia.(in.)	Type
+2.1	80	6"	Steel

PERFS

From (Ft.)	To (Ft.)	Description
80	84.7	4 ½ PVC, Vertical slots cut w/ skill saw

Pump type: ______ Size (HP): ___

Well seal type: Bentonite

Well seal depth: from 0 Ft. to 20 Ft.

Water use: STOCK

Date well completed: 11 day 10 mo. 1995 year

How drilled: Air Rotary

By whom: LINDSAY Licence no.: 253

LITHOLOGIC LOG

From (Ft.)	To (Ft.)	Lithologic Descriptions
0	4	Topsoil
4	16	Clay
16	25	Gravel
25	80	Clay + Sand
80	90	Hard clay and coarse sand

Aquifer: ______ Code: ______

SOURCE

Well appropriation: ☐ MBMG: ☒

Driller: ☒ Owner: ☐ USGS: ☐

SCS: ☐ Other (specify): ______

FIELD DATA

Has well location been field verified?: ☒ yes ☐ no

By whom: R. MARVIN Agency: MBMG

Date verified: 16 day 10 mo. 1995 year

Location of measuring point: Top of Steel Casing

		DAY	MO	YEAR
Measuring point** L.S.:	+2.1 Ft.			
Total depth of well below L.S.:	84.7 Ft.	16	10	1995
Pumping water level below L.S.:	Ft.			
Static water level below* L.S.:	22.6 Ft.	16	10	1995
pH:				
Water temperature:	°C			
Specific conductivity @ 25°C:				
Yield in gallons per minute:				

How measured: ______ hours: ___

FILE DATA

MBMG water well no.(key): 0

MBMG water quality no.(key): ______

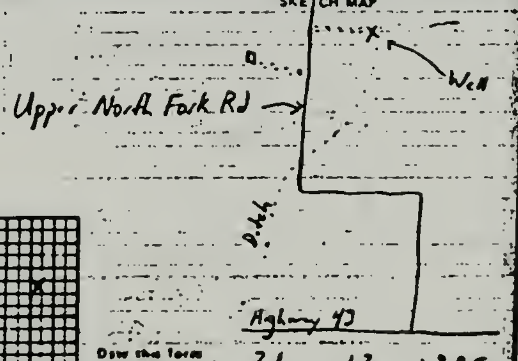
MBMG aquifer test: ☒ yes ☐ no Project no.: 496

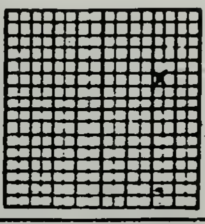
MBMG static water level file: ☒ yes ☐ no

DNRC WR number(key): _____ Geophysics logs: ☐ yes ☒ no

USGS groundwater station ID no.: ______

SKETCH MAP





REMARKS

Stevens Recorder installed 10/19/95.

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* If well is flowing, place a (+) here. If the discharge height above land surface is known, place that value here and precede it by a (+).

** Above (+), below (−) L.S.

Date this form completed: 21 DAY 12 MO. 1995 YEAR

By Rich Marvin MBMG

M: 153311

MONTANA BUREAU OF MINES AND GEOLOGY
WELL DATA SHEET

TOWNSHIP 02 N ☐ S ☑ RANGE 26 E ☐ W ☑ SECTION 25 TRACT ABAB SEQUENCE NO. 01

COUNTY BEAVERHEAD CODE ___

Original owner: JOHN ERB Address: 555 SKYLINE DR., DILLON, MT

Owner (1995 yr.): JOHN ERB Resident (if not owner): SPOKANE RANCH

Addition (if in subdivision): ______ Block: ____ Lot: ____ Other: ______

USGS 7.5' map: GIBBONS SCHOOL, MONT. Lat. 45° 38' 18" N; Lon 113° 31' 02" W

Altitude of Land Surface (L.S.) @ well: ______ Ft.

REPORTED DATA

Total depth of well below L.S.: 203 Ft.

Pumping water level below L.S.: ____ Ft.

Static water level below* L.S.: 32 Ft.

Yield in gallons per minute: 30

How tested: DRILLER ESTIMATE hours: ___

If flowing, shut-in pressure in PSI: ___

CASING

From (Ft.)	To (Ft.)	Dia. (in.)	Type
+1.57	198	6	Steel

PERFS

From (Ft.)	To (Ft.)	Description
198	201	Open hole

Pump type: ______ Size (HP): ___

Well seal type: Bentonite

Well seal depth: from 0 Ft. to 20 Ft.

Water use: Stock

Date well completed: 12 day 10 mo. 1995 year

How drilled: Air Rotary

By whom: Lindsay Licence no.: 253

SOURCE

Well appropriation: ☐ MBMG: ☑

Driller: ☑ Owner: ☐ USGS: ☐

SCS: ☐ Other (specify): ______

FIELD DATA

Has well location been field verified?: ☑ yes ☐ no

By whom: R. MARVIN Agency: MBMG

Date verified: 26 day 10 mo. 1995 year

Location of measuring point: Top of Steel Casing

		Day	Mo	Year
Measuring point** L.S.:	1.6 Ft.			
Total depth of well below L.S.:	201.4 Ft.	20	10	1995
Pumping water level below L.S.:	Ft.			
Static water level below* L.S.:	31.3 Ft.	20	10	1995
pH:	7.2	17	10	1995
Water temperature:	7.9 °C	17	10	1995
Specific conductivity @ 25°C:	244	17	10	1995
Yield in gallons per minute:				

How measured: ______ hours: ___

LITHOLOGIC LOG

From (Ft.)	To (Ft.)	Lithologic Descriptions
0	4	Top soil
4	30	Clay and gravel
30	140	Coarse Sand, some clay
140	180	Brown clay coarse sand
180	200	Mud Stone w/ coarse sand

Aquifer: ______ Code: ______

FILE DATA

MBMG water well no. (key): __ Q ____

MBMG water quality no. (key): ______

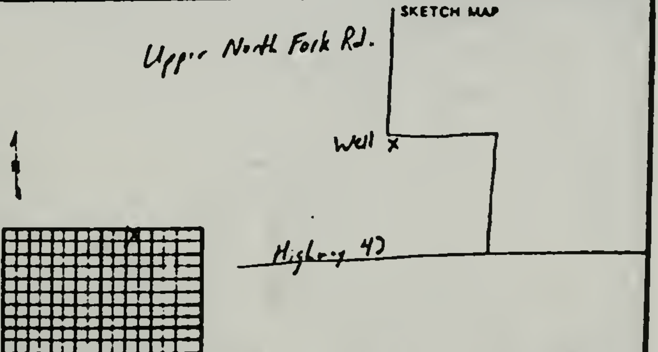
MBMG aquifer test: ☑ yes ☐ no Project no.: 496

MBMG static water level file: ☑ yes ☐ no

DNRC WR number (key): _____ Geophysics logs: ☐ yes ☑ no

USGS groundwater station ID no.: ______

SKETCH MAP



REMARKS

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* If well is flowing, place a (+) here. If the discharge height above land surface is known, place that value here and precede it by a (+).

** Above (+), below (–) L.S.

Date the form completed: 21 DAY 12 MO. 1995 YEAR

By Rich Marvin MBMG

M-153312

MONTANA BUREAU OF MINES AND GEOLOGY
WELL DATA SHEET

TOWNSHIP 02 N ☐ S ☑ RANGE 26 E ☐ W ☑

SECTION 02 TRACT CDBC SEQUENCE NO. 01

COUNTY BEAVERHEAD CODE ___

Original owner: JOHN ERB

Address: 555 SKYLINE DR., DILLON, MT

Owner (1995 yr.): JOHN ERB

Resident (if not owner): SPOKANE RANCH

Addition (if in subdivision): ______ Block: ____ Lot: ____ Other: ______

USGS 7.5' map: GIBBONS SCHOOL, MONT.

Lat. 45° 40' 18" N; Lon 113° 30' 02" W

Altitude of Land Surface (L.S.) @ well: ______ Ft.

REPORTED DATA

Total depth of well below L.S.: 115 Ft.

Pumping water level below L.S.: ____ Ft.

Static water level below* L.S.: 36.1 Ft.

Yield in gallons per minute: 30

How tested: ESTIMATED BY DRILLER hours: ___

If flowing, shut-in pressure in PSI: ___

CASING

From (Ft.)	To (Ft.)	Dia. (in.)	Type
+2.5	-78	6	Steel

PERFS

From (Ft.)	To (Ft.)	Description
-78	-115	4 5/8 PVC, vertical cuts with Skil Saw

Pump type: ______ Size (HP): ___

Well seal type: Bentonite

Well seal depth: from 0 Ft. to 20 Ft.

Water use: STOCK

Date well completed: 19 day 10 mo. 1995 year

How drilled: Air Rotary

By whom: LINDSAY Licence no.: 253

LITHOLOGIC LOG

From (Ft.)	To (Ft.)	Lithologic Descriptions
0	20	Light yellow brown silt and clay, little sand
20	60	Light yellow brown clay, some sand
60	80	Sand, trace gravel
80	100	Sand and gravel
100	120	Brown mudstone with sand

Aquifer: ______ Code: ______

SOURCE

Well appropriation: ☐ MBMG: ☑

Driller: ☑ Owner: ☐ USGS: ☐

SCS: ☐ Other (specify): ______

FIELD DATA

Has well location been field verified? ☑ yes ☐ no

By whom: B. MARVIN Agency: MBMG

Date verified: 19 day 10 mo. 1995 year

Location of measuring point: TOP of Steel Casing

		Day	Mo	Year
Measuring point** L.S.:	+2.5 Ft.			
Total depth of well below L.S.:	114.6 Ft.	19	10	1995
Pumping water level below L.S.:	Ft.			
Static water level below* L.S.:	36.4 Ft.	19	10	1995
pH:	7.7	19	10	1995
Water temperature:	9.2 °C	19	10	1995
Specific conductivity @ 25°C:	180	19	10	1995
Yield in gallons per minute:				
How measured:	hours:			

FILE DATA

MBMG water well no. (key): 0

MBMG water quality no. (key): ______

MBMG aquifer test: ☑ yes ☐ no Project no.: 496

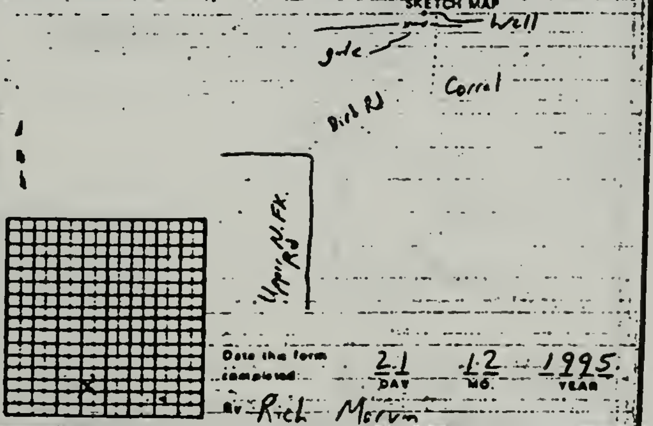
MBMG static water level file: ☑ yes ☐ no

DNRC WR number (key): ______ Geophysics logs: ☐ yes ☑ no

USGS groundwater station ID no.: ______

REMARKS

SKETCH MAP



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* If well is flowing, place a (+) here. If the discharge height above land surface is known, place that value here and precede it by a (+).

** Above (+), below (-) L.S.

Date the form completed: 21 DAY 12 MO. 1995 YEAR

By Rich Marvin

M: 153313

MONTANA BUREAU OF MINES AND GEOLOGY
WELL DATA SHEET

TOWNSHIP 02 N ☐ S ☒ RANGE 15 E ☐ W ☒ SECTION 32 TRACT CCCC SEQUENCE NO. 01

COUNTY BEAVERHEAD CODE ___

Original owner: JOHN ERB Address: 555 SKYLINE DR., DILLON MT

Owner (1995 yr.): JOHN ERB Resident (if not owner): SPOKANE RANCH

Addition (if in subdivision): ______ Block: ____ Lot: ____ Other: ____

USGS 7.5' map: WISDOM, MONT Lat. 45° 36' 40" N; Lon 113° 22' 24" W

Altitude of Land Surface (L.S.) @ well: ______ Ft.

REPORTED DATA

Total depth of well below L.S.: 185 Ft.

Pumping water level below L.S.: ____ Ft.

Static water level below* L.S.: 12 Ft.

Yield in gallons per minute: 30

How tested: ESTIMATED BY DRILLER hours: ___

If flowing, shut-in pressure in PSI: ___

CASING

From (Ft.)	To (Ft.)	Dia.(in.)	Type
+2	180	6	Steel

PERFS

From (Ft.)	To (Ft.)	Description
180	185	4½ PVC, Vertical Slots cut with Skil saw

Pump type: ________ Size (HP): ___

Well seal type: Bentonite

Well seal depth: from 0 Ft. to 20 Ft.

Water use: STOCK

Date well completed: 24 day 10 mo. 1995 year

How drilled: Air Rotary

By whom: LINDSAY Licence no.: 253

LITHOLOGIC LOG

From (Ft.)	To (Ft.)	Lithologic Descriptions
0	5	Top Soil (Loam)
5	20	Sand and Gravel (Well rounded)
20	25	Sand and gravel, little silt and clay
25	40	Sand, little silt and clay
40	60	Sand, little pea gravel, trace silt and clay
60	70	Sand
70	80	Coarse Sand, little gravel
80	170	Sand and silt
170	185	Soft Mudstone

Aquifer: ____ Code: ____

SOURCE

Well appropriation: ☐ MBMG: ☐

Driller: ☐ Owner: ☐ USGS: ☐

SCS: ☐ Other (specify): ____

FIELD DATA

Has well location been field verified?: ☒ yes ☐ no

By whom: R. MARVIN Agency: MBMG

Date verified: 20 day 10 mo. 1995 year

Location of measuring point: Top of Steel Casing

Measuring point** L.S.: ____ Ft.

Total depth of well below L.S.: ____ Ft.

Pumping water level below L.S.: ____ Ft.

Static water level below* L.S.: ____ Ft.

pH: ____

Water temperature: ____ °C

Specific conductivity @ 25°C: ____

Yield in gallons per minute: ____

How measured: ____ hours: ____

DATE MEASURED		
DAY	MO	YEAR

FILE DATA

MBMG water well no.(key): 0

MBMG water quality no.(key): ____

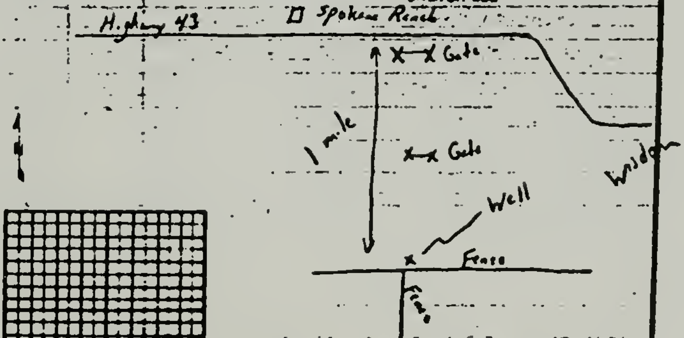
MBMG aquifer test: ☐ yes ☒ no Project no.: ____

MBMG static water level file: ☒ yes ☐ no

DNRC WR number(key): ____ Geophysics logs: ☐ yes ☒ no

USGS groundwater station ID no.: ____

SKETCH MAP



REMARKS

Well in pasture. Difficult to locate.

* If well is flowing, place a (+) here. If the discharge height above land surface is known, place that value here and precede it by a (+).

** Above (+), below (−) L.S.

Date this form completed: 21 DAY 12 MO. 1995 YEAR

By R.L MARVIN MBMG

APPENDIX C: WATER-LEVEL DATA

Well M:108610

Location: 05S15W36CABD

Note: Water levels collected with digital Stevens Recorder.

Elevation: 6565 ft

Date	Water Level (ft)	Water Level Altitude (ft)	Date	Water Level (ft)	Water Level Altitude (ft)	Date	Water Level (ft)	Water Level Altitude (ft)
3/22/95	15.18	6549.8	10/3/95	24.79	6540.2	11/11/95	25.88	6539.1
6/26/95	4.08	6560.9	10/4/95	24.83	6540.2	11/12/95	25.90	6539.1
8/29/95	20.51	6544.5	10/5/95	24.89	6540.1	11/13/95	25.91	6539.1
8/30/95	20.79	6544.2	10/6/95	24.92	6540.1	11/14/95	25.93	6539.1
8/31/95	21.08	6543.9	10/7/95	24.96	6540.0	11/15/95	25.94	6539.1
9/1/95	21.36	6543.6	10/8/95	25.00	6540.0	11/16/95	25.95	6539.1
9/2/95	21.63	6543.4	10/9/95	25.04	6540.0	11/17/95	25.97	6539.0
9/3/95	21.89	6543.1	10/10/95	25.09	6539.9	11/18/95	25.98	6539.0
9/4/95	22.14	6542.9	10/11/95	25.12	6539.9	11/19/95	25.99	6539.0
9/5/95	22.35	6542.7	10/12/95	25.16	6539.8	11/20/95	26.00	6539.0
9/6/95	22.55	6542.5	10/13/95	25.20	6539.8	11/21/95	26.01	6539.0
9/7/95	22.70	6542.3	10/14/95	25.23	6539.8	11/22/95	26.02	6539.0
9/8/95	22.84	6542.2	10/15/95	25.26	6539.7	11/23/95	26.03	6539.0
9/9/95	22.98	6542.0	10/16/95	25.29	6539.7	11/24/95	26.04	6539.0
9/10/95	23.10	6541.9	10/17/95	25.31	6539.7	11/25/95	26.05	6539.0
9/11/95	23.23	6541.8	10/18/95	25.35	6539.7	11/26/95	26.06	6538.9
9/12/95	23.35	6541.7	10/19/95	25.40	6539.6	11/27/95	26.06	6538.9
9/13/95	23.46	6541.5	10/20/95	25.42	6539.6	12/18/95	26.28	6538.7
9/14/95	23.54	6541.5	10/21/95	25.44	6539.6	12/28/95	26.44	6538.6
9/14/95	23.60	6541.4	10/22/95	25.47	6539.5	12/29/95	26.44	6538.6
9/14/95	23.61	6541.4	10/23/95	25.50	6539.5	12/30/95	26.44	6538.6
9/15/95	23.67	6541.3	10/24/95	25.52	6539.5	12/31/95	26.44	6538.6
9/16/95	23.76	6541.2	10/25/95	25.55	6539.5	1/1/96	26.45	6538.6
9/17/95	23.85	6541.2	10/26/95	25.57	6539.4	1/2/96	26.46	6538.5
9/18/95	23.94	6541.1	10/27/95	25.59	6539.4	1/3/96	26.47	6538.5
9/19/95	24.02	6541.0	10/28/95	25.62	6539.4	1/4/96	26.47	6538.5
9/20/95	24.10	6540.9	10/29/95	25.64	6539.4	1/5/96	26.48	6538.5
9/21/95	24.18	6540.8	10/30/95	25.66	6539.3	1/6/96	26.49	6538.5
9/22/95	24.24	6540.8	10/31/95	25.68	6539.3	1/7/96	26.50	6538.5
9/23/95	24.29	6540.7	11/1/95	25.70	6539.3	1/8/96	26.51	6538.5
9/24/95	24.36	6540.6	11/2/95	25.72	6539.3	1/9/96	26.51	6538.5
9/25/95	24.41	6540.6	11/3/95	25.75	6539.3	1/10/96	26.53	6538.5
9/26/95	24.46	6540.5	11/4/95	25.76	6539.2	1/11/96	26.53	6538.5
9/27/95	24.53	6540.5	11/5/95	25.78	6539.2	1/12/96	26.54	6538.5
9/28/95	24.57	6540.4	11/6/95	25.80	6539.2	1/13/96	26.55	6538.5
9/29/95	24.62	6540.4	11/7/95	25.82	6539.2	1/14/96	26.56	6538.4
9/30/95	24.67	6540.3	11/8/95	25.83	6539.2	1/15/96	26.57	6538.4
10/1/95	24.72	6540.3	11/9/95	25.85	6539.2	1/16/96	26.57	6538.4
10/2/95	24.76	6540.2	11/10/95	25.86	6539.1	1/17/96	26.58	6538.4

Date	Water Level (ft)	Water Level Altitude (ft)	Date	Water Level (ft)	Water Level Altitude (ft)	Date	Water Level (ft)	Water Level Altitude (ft)
1/18/96	26.59	6538.4	3/3/96	26.72	6538.3	4/19/96	18.42	6546.6
1/19/96	26.59	6538.4	3/4/96	26.73	6538.3	4/20/96	18.65	6546.4
1/20/96	26.60	6538.4	3/5/96	26.74	6538.3	4/21/96	18.92	6546.1
1/21/96	26.61	6538.4	3/6/96	26.76	6538.2	4/22/96	19.18	6545.8
1/22/96	26.62	6538.4	3/7/96	26.78	6538.2	4/23/96	19.41	6545.6
1/23/96	26.62	6538.4	3/8/96	26.79	6538.2	4/24/96	19.61	6545.4
1/24/96	26.63	6538.4	3/9/96	26.79	6538.2	4/25/96	19.87	6545.1
1/25/96	26.64	6538.4	3/10/96	26.80	6538.2	4/26/96	20.08	6544.9
1/26/96	26.65	6538.4	3/11/96	26.81	6538.2	4/27/96	20.26	6544.7
1/27/96	26.65	6538.4	3/12/96	26.77	6538.2	4/28/96	20.50	6544.5
1/28/96	26.66	6538.3	3/13/96	24.14	6540.9	4/29/96	20.66	6544.3
1/29/96	26.67	6538.3	3/16/96	19.39	6545.6	4/30/96	20.80	6544.2
1/30/96	26.68	6538.3	3/17/96	19.31	6545.7	5/1/96	20.93	6544.1
1/31/96	26.69	6538.3	3/18/96	19.52	6545.5	5/2/96	21.08	6543.9
2/1/96	26.70	6538.3	3/19/96	19.46	6545.5	5/3/96	21.22	6543.8
2/2/96	26.71	6538.3	3/20/96	18.76	6546.2	5/4/96	21.38	6543.6
2/3/96	26.72	6538.3	3/21/96	17.23	6547.8	5/5/96	21.53	6543.5
2/4/96	26.72	6538.3	3/22/96	15.92	6549.1	5/6/96	21.66	6543.3
2/5/96	26.74	6538.3	3/23/96	15.20	6549.8	5/7/96	21.77	6543.2
2/6/96	26.74	6538.3	3/24/96	15.24	6549.8	5/8/96	21.90	6543.1
2/7/96	26.75	6538.3	3/25/96	15.76	6549.2	5/9/96	22.04	6543.0
2/8/96	26.76	6538.2	3/26/96	16.24	6548.8	5/10/96	22.18	6542.8
2/9/96	26.77	6538.2	3/27/96	16.65	6548.4	5/11/96	22.32	6542.7
2/10/96	26.78	6538.2	3/28/96	17.01	6548.0	5/12/96	21.94	6543.1
2/11/96	26.78	6538.2	3/29/96	17.38	6547.6	5/13/96	13.14	6551.9
2/12/96	26.78	6538.2	3/30/96	17.74	6547.3	5/14/96	10.63	6554.4
2/13/96	26.76	6538.2	3/31/96	18.04	6547.0	5/15/96	9.41	6555.6
2/14/96	26.73	6538.3	4/1/96	18.13	6546.9	5/16/96	6.26	6558.7
2/15/96	26.72	6538.3	4/2/96	17.35	6547.7	5/17/96	5.58	6559.4
2/16/96	26.70	6538.3	4/3/96	16.64	6548.4	5/18/96	5.28	6559.7
2/17/96	26.68	6538.3	4/4/96	16.15	6548.9	5/19/96	5.14	6559.9
2/18/96	26.67	6538.3	4/5/96	15.88	6549.1	5/20/96	5.03	6560.0
2/19/96	26.65	6538.4	4/6/96	15.65	6549.4	5/21/96	4.66	6560.3
2/20/96	26.64	6538.4	4/7/96	15.13	6549.9	5/22/96	4.38	6560.6
2/21/96	26.64	6538.4	4/8/96	14.78	6550.2	5/23/96	4.28	6560.7
2/22/96	26.64	6538.4	4/9/96	14.71	6550.3	5/24/96	4.25	6560.8
2/23/96	26.64	6538.4	4/10/96	14.99	6550.0	5/25/96	4.19	6560.8
2/24/96	26.64	6538.4	4/11/96	15.37	6549.6	5/26/96	4.13	6560.9
2/25/96	26.64	6538.4	4/12/96	15.83	6549.2	5/27/96	4.09	6560.9
2/26/96	26.64	6538.4	4/13/96	16.35	6548.7	5/28/96	4.07	6560.9
2/27/96	26.65	6538.4	4/14/96	16.82	6548.2	5/29/96	4.07	6560.9
2/28/96	26.66	6538.3	4/15/96	17.20	6547.8	5/30/96	4.09	6560.9
2/29/96	26.68	6538.3	4/16/96	17.47	6547.5	5/31/96	4.10	6560.9
3/1/96	26.69	6538.3	4/17/96	17.79	6547.2	6/1/96	4.12	6560.9
3/2/96	26.71	6538.3	4/18/96	18.10	6546.9	6/2/96	4.12	6560.9

Date	Water Level (ft)	Water Level Altitude (ft)	Date	Water Level (ft)	Water Level Altitude (ft)	Date	Water Level (ft)	Water Level Altitude (ft)
6/3/96	4.12	6560.9	7/19/96	9.55	6555.5	9/2/96	22.31	6542.7
6/4/96	4.23	6560.8	7/20/96	9.88	6555.1	9/3/96	22.50	6542.5
6/5/96	4.39	6560.6	7/21/96	10.21	6554.8	9/4/96	22.66	6542.3
6/6/96	4.34	6560.7	7/22/96	10.55	6554.5	9/5/96	22.80	6542.2
6/7/96	4.14	6560.9	7/23/96	10.88	6554.1	9/6/96	22.94	6542.1
6/8/96	4.04	6561.0	7/24/96	11.19	6553.8	9/7/96	23.06	6541.9
6/9/96	3.99	6561.0	7/25/96	11.48	6553.5	9/8/96	23.19	6541.8
6/10/96	4.01	6561.0	7/26/96	11.80	6553.2	9/9/96	23.30	6541.7
6/11/96	4.02	6561.0	7/27/96	12.12	6552.9	9/10/96	23.41	6541.6
6/12/96	4.07	6560.9	7/28/96	12.43	6552.6	9/11/96	23.52	6541.5
6/13/96	4.11	6560.9	7/29/96	12.74	6552.3	9/12/96	23.61	6541.4
6/14/96	4.15	6560.9	7/30/96	13.03	6552.0	9/13/96	23.69	6541.3
6/15/96	4.17	6560.8	7/31/96	13.30	6551.7	9/14/96	23.77	6541.2
6/16/96	4.08	6560.9	8/1/96	13.55	6551.5	9/15/96	23.84	6541.2
6/17/96	4.03	6561.0	8/2/96	13.79	6551.2	9/16/96	23.92	6541.1
6/18/96	4.08	6560.9	8/3/96	14.05	6551.0	9/17/96	24.01	6541.0
6/20/96	4.12	6560.9	8/4/96	14.31	6550.7	9/18/96	24.08	6540.9
6/21/96	4.14	6560.9	8/5/96	14.57	6550.4	9/19/96	24.15	6540.9
6/22/96	4.18	6560.8	8/6/96	14.90	6550.1	9/20/96	24.21	6540.8
6/23/96	4.21	6560.8	8/7/96	15.22	6549.8	9/21/96	24.27	6540.7
6/24/96	4.23	6560.8	8/8/96	15.52	6549.5	9/22/96	24.32	6540.7
6/25/96	4.19	6560.8	8/9/96	15.81	6549.2	9/23/96	24.36	6540.6
6/26/96	4.16	6560.8	8/10/96	16.09	6548.9			
6/27/96	4.19	6560.8	8/11/96	16.37	6548.6			
6/28/96	4.26	6560.7	8/12/96	16.64	6548.4			
6/29/96	4.33	6560.7	8/13/96	16.93	6548.1			
6/30/96	4.35	6560.7	8/14/96	17.22	6547.8			
7/1/96	4.09	6560.9	8/15/96	17.49	6547.5			
7/2/96	4.40	6560.6	8/16/96	17.74	6547.3			
7/3/96	4.44	6560.6	8/17/96	17.97	6547.0			
7/4/96	4.46	6560.5	8/18/96	18.22	6546.8			
7/5/96	4.51	6560.5	8/19/96	18.50	6546.5			
7/6/96	4.57	6560.4	8/20/96	18.75	6546.3			
7/7/96	4.62	6560.4	8/21/96	19.03	6546.0			
7/8/96	4.66	6560.3	8/22/96	19.32	6545.7			
7/9/96	4.65	6560.4	8/23/96	19.64	6545.4			
7/10/96	4.93	6560.1	8/24/96	19.94	6545.1			
7/11/96	6.01	6559.0	8/25/96	20.24	6544.8			
7/12/96	6.86	6558.1	8/26/96	20.53	6544.5			
7/13/96	7.47	6557.5	8/27/96	20.82	6544.2			
7/14/96	7.90	6557.1	8/28/96	21.11	6543.9			
7/15/96	8.26	6556.7	8/29/96	21.40	6543.6			
7/16/96	8.59	6556.4	8/30/96	21.65	6543.4			
7/17/96	8.90	6556.1	8/31/96	21.86	6543.1			
7/18/96	9.26	6555.7	9/1/96	22.09	6542.9			

Well M:153310

Location: 02S16W24ADBC

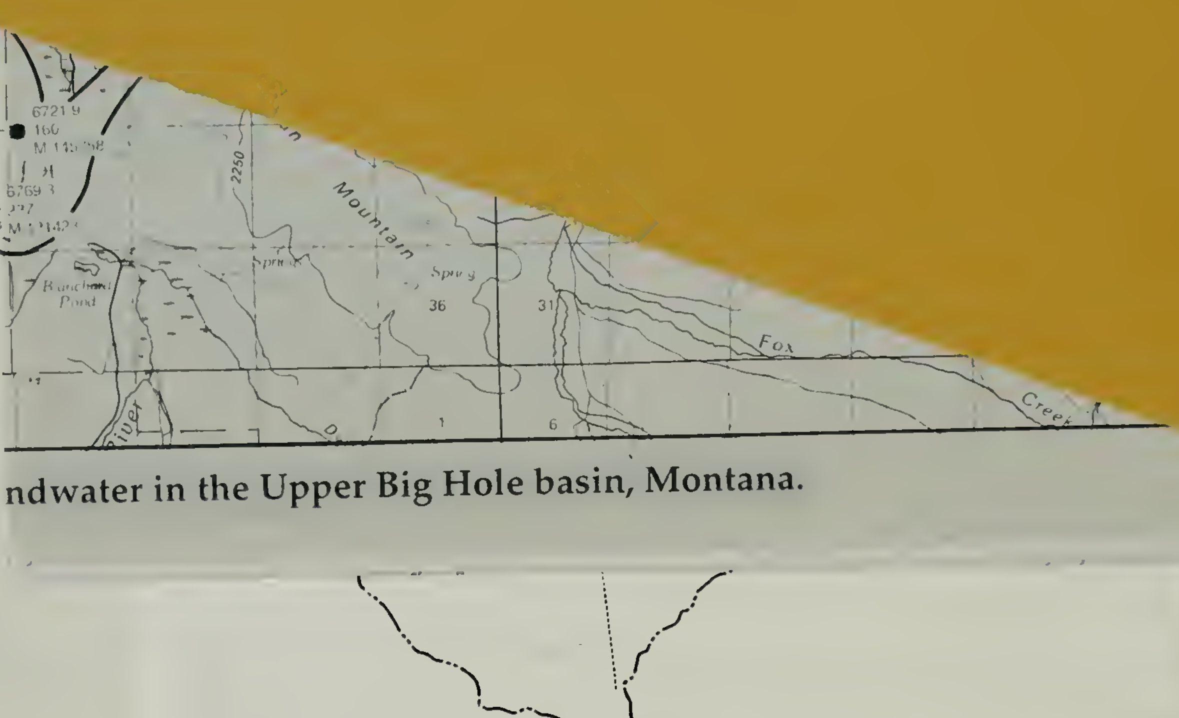
Note: * Water level measurements collected with electric tape.
All other measurements collected with Stevens Recorder.

Elevation: 6078 ft

Date	Time	Water Level (ft)	Water Level Altitude (ft)
10/16/95	16:00	24.69	6053.3 *
10/19/95	15:50	25.07	6052.9 *
10/19/95	17:30	25.11	6052.9
10/20/95	5:30	25.04	6053.0
10/20/95	17:30	24.98	6053.0
10/21/95	5:30	24.93	6053.1
10/21/95	17:30	24.92	6053.1
10/22/95	5:30	25.02	6053.0
10/22/95	17:30	25.16	6052.8
10/23/95	5:30	25.20	6052.8
10/23/95	17:30	25.19	6052.8
10/24/95	5:30	25.15	6052.9
10/24/95	17:30	25.17	6052.8
10/25/95	5:30	25.20	6052.8
10/25/95	17:30	25.21	6052.8
10/26/95	5:30	25.16	6052.8
10/26/95	17:30	25.25	6052.8
10/27/95	5:30	25.37	6052.6
10/27/95	17:30	25.40	6052.6
10/28/95	5:30	25.40	6052.6
10/28/95	17:30	25.40	6052.6
10/29/95	5:30	25.41	6052.6
10/29/95	17:30	25.44	6052.6
10/30/95	5:30	25.48	6052.5
10/30/95	17:30	25.49	6052.5
10/31/95	5:30	25.48	6052.5
10/31/95	17:30	25.46	6052.5
11/1/95	5:30	25.69	6052.3
11/1/95	17:30	25.71	6052.3
11/2/95	5:30	25.74	6052.3
11/2/95	17:30	25.74	6052.3
11/3/95	5:30	25.78	6052.2
11/3/95	17:30	25.80	6052.2
11/4/95	5:30	25.79	6052.2
11/4/95	17:30	25.68	6052.3
11/5/95	5:30	25.68	6052.3
11/5/95	17:30	25.77	6052.2
11/6/95	5:30	25.78	6052.2
11/6/95	17:30	25.95	6052.1
11/7/95	5:30	25.97	6052.0
11/7/95	17:30	25.97	6052.0
11/8/95	5:30	26.02	6052.0
11/8/95	17:30	25.86	6052.1
11/9/95	5:30	25.84	6052.2
11/9/95	17:30	25.92	6052.1
11/10/95	5:30	25.99	6052.0
11/10/95	17:30	26.09	6051.9
11/11/95	5:30	26.15	6051.9
11/11/95	17:30	26.12	6051.9
11/12/95	5:30	26.14	6051.9
11/12/95	17:30	26.23	6051.8
11/13/95	5:30	26.30	6051.7
11/13/95	17:30	26.33	6051.7
11/14/95	5:30	26.34	6051.7
11/14/95	17:30	26.34	6051.7
11/15/95	5:30	26.35	6051.7
11/15/95	17:30	26.34	6051.7
11/16/95	5:30	26.30	6051.7
11/16/95	17:30	26.40	6051.6
11/17/95	5:30	26.40	6051.6
11/17/95	17:30	26.38	6051.6
11/18/95	5:30	26.26	6051.7
11/18/95	17:30	26.32	6051.7
11/19/95	5:30	26.39	6051.6
11/19/95	17:30	26.41	6051.6
11/20/95	5:30	26.45	6051.6
11/20/95	17:30	26.47	6051.5
11/21/95	5:30	26.36	6051.6
11/21/95	17:30	26.29	6051.7
11/22/95	5:30	26.37	6051.6
11/22/95	17:30	26.41	6051.6
11/23/95	5:30	26.47	6051.5
11/23/95	17:30	26.47	6051.5
11/24/95	5:30	26.43	6051.6
11/24/95	17:30	26.42	6051.6
11/25/95	5:30	26.35	6051.7
11/25/95	17:30	26.35	6051.7
11/26/95	5:30	26.33	6051.7
11/26/95	17:30	26.47	6051.5
11/27/95	5:30	26.55	6051.5
11/27/95	17:30	26.48	6051.5
11/28/95	5:30	26.36	6051.6
11/28/95	17:30	26.43	6051.6
11/29/95	5:30	26.57	6051.4
11/29/95	17:30	26.61	6051.4
11/30/95	5:30	26.62	6051.4
11/30/95	17:30	26.57	6051.4
12/1/95	5:30	26.66	6051.3
12/1/95	17:30	26.70	6051.3
12/2/95	5:30	26.74	6051.3
12/2/95	17:30	26.75	6051.3
12/3/95	5:30	26.62	6051.4
12/3/95	17:30	26.86	6051.1
12/4/95	5:30	26.84	6051.2
12/4/95	17:30	26.72	6051.3
12/5/95	5:30	26.79	6051.2
12/5/95	17:30	26.79	6051.2
12/6/95	5:30	26.64	6051.4
12/6/95	17:30	26.74	6051.3
12/7/95	5:30	26.82	6051.2
12/7/95	17:30	26.84	6051.2
12/8/95	5:30	26.84	6051.2
12/8/95	17:30	26.81	6051.2
12/9/95	5:30	26.79	6051.2
12/9/95	17:30	26.71	6051.3
12/10/95	5:30	26.74	6051.3
12/10/95	17:30	26.70	6051.3
12/11/95	5:30	26.55	6051.5
12/11/95	17:30	26.66	6051.3
12/12/95	5:30	26.79	6051.2
12/12/95	17:30	26.83	6051.2
12/13/95	5:30	26.95	6051.1
12/13/95	17:30	26.99	6051.0
12/14/95	5:30	26.98	6051.0
12/14/95	17:30	26.93	6051.1
12/15/95	5:30	26.97	6051.0
12/15/95	17:30	27.01	6051.0
12/16/95	5:30	27.06	6050.9
12/16/95	17:30	27.07	6050.9
12/17/95	5:30	27.06	6050.9
12/17/95	17:30	27.05	6051.0
12/18/95	13:20	26.71	6051.3 *
12/18/95	14:00	26.70	6051.3
12/19/95	14:00	26.69	6051.3
12/20/95	14:00	26.72	6051.3
12/21/95	14:00	26.75	6051.3
12/22/95	14:00	26.82	6051.2
12/23/95	14:00	26.83	6051.2
12/24/95	14:00	26.90	6051.1
12/25/95	14:00	27.02	6051.0
12/26/95	14:00	27.01	6051.0
12/27/95	14:00	27.00	6051.0
12/28/95	14:00	26.98	6051.0
12/29/95	14:00	27.01	6051.0
12/30/95	14:00	26.96	6051.0
12/31/95	14:00	26.96	6051.0
1/1/96	14:00	27.27	6050.7
1/2/96	14:00	27.27	6050.7
1/3/96	14:00	27.13	6050.9
1/4/96	14:00	27.11	6050.9
1/5/96	14:00	27.37	6050.6
1/6/96	14:00	27.51	6050.5
1/7/96	14:00	27.50	6050.5
1/8/96	14:00	27.47	6050.5
1/9/96	14:00	27.57	6050.4
1/10/96	14:00	27.53	6050.5
1/11/96	14:00	27.77	6050.2
1/12/96	14:00	27.77	6050.2
1/13/96	14:00	27.68	6050.3
1/14/96	14:00	27.71	6050.3
1/15/96	14:00	27.73	6050.3
1/16/96	14:00	27.70	6050.3
1/17/96	14:00	27.58	6050.4
1/18/96	14:00	28.02	6050.0
1/19/96	14:00	27.84	6050.2
1/20/96	14:00	27.84	6050.2
1/21/96	14:00	27.91	6050.1
1/22/96	14:00	28.09	6049.9
1/23/96	14:00	28.16	6049.8
1/24/96	14:00	28.14	6049.9
1/25/96	14:00	28.11	6049.9
1/26/96	14:00	28.34	6049.7

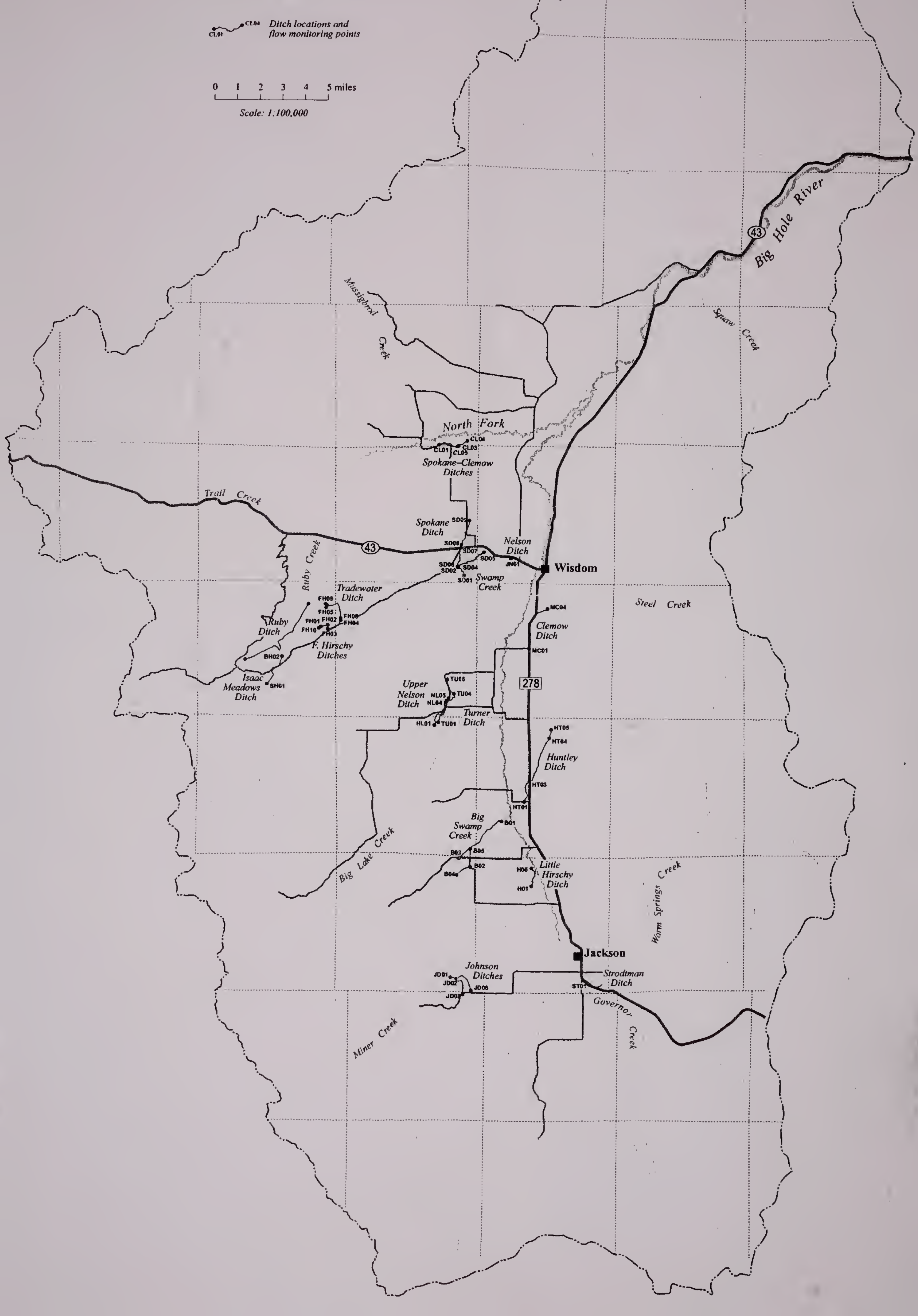
Date	Time	Water Level (ft)	Water Level Altitude (ft)	Date	Time	Water Level (ft)	Water Level Altitude (ft)	Date	Time	Water Level (ft)	Water Level Altitude (ft)
1/27/96	14:00	28.35	6049.7	3/25/96	16:00	30.36	6047.6	5/21/96	16:00	28.97	6049.0
1/28/96	14:00	28.17	6049.8	3/26/96	16:00	30.20	6047.8	5/21/96	20:30	28.99	6049.0 *
1/29/96	14:00	28.40	6049.6	3/27/96	16:00	30.21	6047.8	5/22/96	16:00	29.03	6049.0
1/30/96	14:00	28.53	6049.5	3/28/96	16:00	30.19	6047.8	5/23/96	16:00	29.09	6048.9
1/31/96	14:00	28.58	6049.4	3/29/96	16:00	30.33	6047.7	5/24/96	16:00	29.06	6048.9
2/1/96	14:00	28.60	6049.4	3/30/96	16:00	30.38	6047.6	5/25/96	16:00	28.96	6049.0
2/2/96	14:00	28.77	6049.2	3/31/96	16:00	30.33	6047.7	5/26/96	16:00	28.94	6049.1
2/3/96	14:00	28.77	6049.2	4/1/96	16:00	30.30	6047.7	5/27/96	16:00	28.89	6049.1
2/4/96	14:00	28.78	6049.2	4/2/96	16:00	30.42	6047.6	5/28/96	16:00	28.89	6049.1
2/5/96	14:00	28.81	6049.2	4/3/96	16:00	30.51	6047.5	5/29/96	16:00	28.91	6049.1
2/6/96	14:00	28.79	6049.2	4/4/96	16:00	30.60	6047.4	5/30/96	16:00	28.88	6049.1
2/7/96	14:00	28.79	6049.2	4/5/96	16:00	30.59	6047.4	5/31/96	16:00	28.89	6049.1
2/8/96	14:00	28.86	6049.1	4/6/96	16:00	30.48	6047.5	6/1/96	16:00	28.88	6049.1
2/9/96	14:00	28.85	6049.2	4/7/96	16:00	30.38	6047.6	6/2/96	16:00	28.76	6049.2
2/10/96	14:00	29.07	6048.9	4/8/96	16:00	30.35	6047.7	6/3/96	16:00	28.70	6049.3
2/11/96	14:00	29.23	6048.8	4/9/96	16:00	30.22	6047.8	6/4/96	16:00	28.46	6049.5
2/12/96	14:00	29.20	6048.8	4/10/96	16:00	30.17	6047.8	6/5/96	16:00	28.25	6049.8
2/13/96	14:00	29.15	6048.9	4/11/96	16:00	30.18	6047.8	6/6/96	16:00	27.86	6050.1
2/14/96	14:00	29.09	6048.9	4/12/96	16:00	30.10	6047.9	6/7/96	16:00	27.51	6050.5
2/15/96	14:00	29.13	6048.9	4/13/96	16:00	30.20	6047.8	6/8/96	16:00	27.25	6050.8
2/16/96	14:00	29.19	6048.8	4/14/96	16:00	30.08	6047.9	6/9/96	16:00	26.84	6051.2
2/17/96	14:00	29.16	6048.8	4/15/96	16:00	29.85	6048.2	6/10/96	16:00	26.82	6051.2
2/18/96	14:00	29.09	6048.9	4/16/96	16:00	29.80	6048.2	6/11/96	16:00	26.78	6051.2
2/19/96	14:00	29.09	6048.9	4/17/96	16:00	29.86	6048.1	6/12/96	16:00	26.59	6051.4
2/20/96	14:00	29.12	6048.9	4/18/96	16:00	29.88	6048.1	6/13/96	16:00	26.35	6051.7
2/21/96	14:00	29.20	6048.8	4/19/96	16:00	29.85	6048.2	6/14/96	16:00	26.12	6051.9
2/22/96	14:00	29.20	6048.8	4/20/96	16:00	29.79	6048.2	6/15/96	16:00	25.87	6052.1
2/23/96	14:00	29.38	6048.6	4/21/96	16:00	29.82	6048.2	6/16/96	16:00	25.62	6052.4
2/24/96	14:00	29.30	6048.7	4/22/96	16:00	29.78	6048.2	6/17/96	16:00	25.48	6052.5
2/25/96	14:00	29.37	6048.6	4/23/96	16:00	29.73	6048.3	6/18/96	16:00	25.36	6052.6
2/26/96	14:00	29.45	6048.6	4/24/96	16:00	29.62	6048.4	6/19/96	11:20	25.24	6052.8 *
2/27/96	14:00	29.50	6048.5	4/25/96	16:00	29.76	6048.2	6/19/96	16:00	25.23	6052.8
2/28/96	14:00	29.58	6048.4	4/26/96	16:00	29.65	6048.4	6/20/96	16:00	24.95	6053.0
2/29/96	14:00	29.68	6048.3	4/27/96	16:00	29.61	6048.4	6/21/96	8:15	24.91	6053.1 *
3/1/96	14:00	29.71	6048.3	4/28/96	16:00	29.69	6048.3	6/21/96	16:00	24.89	6053.1
3/2/96	14:00	29.67	6048.3	4/29/96	16:00	29.52	6048.5	6/22/96	16:00	24.67	6053.3
3/3/96	14:00	29.59	6048.4	4/30/96	16:00	29.43	6048.6	6/23/96	16:00	24.60	6053.4
3/4/96	14:00	29.58	6048.4	5/1/96	16:00	29.42	6048.6	6/24/96	16:00	24.42	6053.6
3/5/96	14:00	29.55	6048.5	5/2/96	16:00	29.38	6048.6	6/25/96	16:00	24.19	6053.8
3/6/96	14:00	29.90	6048.1	5/3/96	16:00	29.38	6048.6	6/26/96	16:00	24.12	6053.9
3/7/96	14:00	29.98	6048.0	5/4/96	16:00	29.42	6048.6	6/27/96	16:00	24.00	6054.0
3/8/96	14:00	29.99	6048.0	5/5/96	16:00	29.38	6048.6	6/28/96	16:00	23.97	6054.0
3/9/96	14:00	30.02	6048.0	5/6/96	16:00	29.30	6048.7	6/29/96	16:00	23.93	6054.1
3/10/96	14:00	29.99	6048.0	5/7/96	16:00	29.31	6048.7	6/30/96	16:00	23.81	6054.2
3/11/96	14:00	29.98	6048.0	5/8/96	10:45	29.34	6048.7 *	7/1/96	16:00	23.66	6054.3
3/12/96	14:00	29.97	6048.0	5/8/96	16:00	29.33	6048.7	7/2/96	16:00	23.54	6054.5
3/13/96	14:00	30.00	6048.0	5/9/96	10:15	29.38	6048.6 *	7/3/96	16:00	23.40	6054.6
3/13/96	15:35		6078.0 *	5/9/96	16:00	29.38	6048.6	7/4/96	16:00	23.33	6054.7
3/14/96	16:00	30.17	6047.8	5/10/96	16:00	29.40	6048.6	7/5/96	16:00	23.29	6054.7
3/15/96	16:00	30.08	6047.9	5/11/96	16:00	29.38	6048.6	7/6/96	16:00	23.27	6054.7
3/16/96	16:00	30.17	6047.8	5/12/96	16:00	29.29	6048.7	7/7/96	16:00	23.04	6055.0
3/17/96	16:00	30.23	6047.8	5/13/96	16:00	29.18	6048.8	7/8/96	16:00	22.96	6055.0
3/18/96	16:00	30.33	6047.7	5/14/96	16:00	29.20	6048.8	7/9/96	16:00	22.97	6055.0
3/19/96	16:00	30.26	6047.7	5/15/96	16:00	29.20	6048.8	7/10/96	16:00	23.02	6055.0
3/20/96	16:00	30.22	6047.8	5/16/96	16:00	29.16	6048.8	7/11/96	16:00	23.03	6055.0
3/21/96	16:00	30.22	6047.8	5/17/96	16:00	29.12	6048.9	7/12/96	16:00	23.05	6054.9
3/22/96	16:00	30.04	6048.0	5/18/96	16:00	29.15	6048.9	7/13/96	16:00	23.14	6054.9
3/23/96	16:00	30.28	6047.7	5/19/96	16:00	29.18	6048.8	7/14/96	16:00	23.20	6054.8
3/24/96	16:00	30.35	6047.7	5/20/96	16:00	29.15	6048.9	7/15/96	16:00	23.24	6054.8

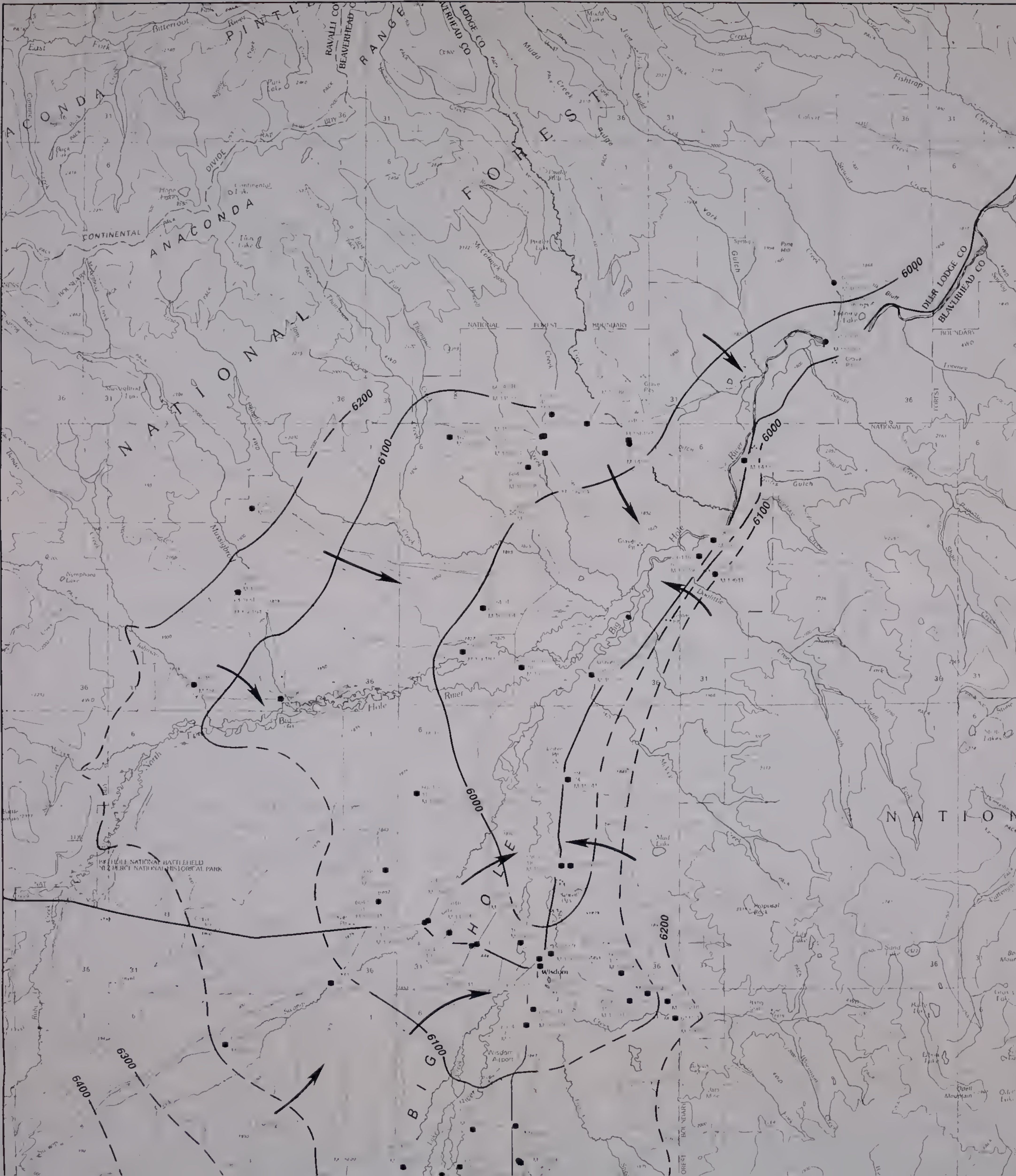
Date	Time	Water Level (ft)	Water Level Altitude (ft)
7/16/96	16:00	23.32	6054.7
7/17/96	8:45	23.42	6054.6 *
7/17/96	16:00	23.40	6054.6
7/18/96	16:00	23.55	6054.4
7/19/96	16:00	23.60	6054.4
7/20/96	16:00	23.71	6054.3
7/21/96	16:00	23.79	6054.2
7/22/96	16:00	23.84	6054.2
7/23/96	16:00	23.90	6054.1
7/24/96	16:00	23.89	6054.1
7/25/96	16:00	24.01	6054.0
7/26/96	16:00	24.08	6053.9
7/27/96	16:00	24.12	6053.9
7/28/96	16:00	24.21	6053.8
7/29/96	16:00	24.28	6053.7
7/30/96	16:00	24.32	6053.7
7/31/96	16:00	24.31	6053.7
8/1/96	16:00	24.30	6053.7
8/2/96	16:00	24.35	6053.6
8/3/96	16:00	24.43	6053.6
8/4/96	16:00	24.48	6053.5
8/5/96	16:00	24.48	6053.5
8/6/96	16:00	24.75	6053.2
8/7/96	16:00	24.83	6053.2
8/8/96	16:00	24.87	6053.1
8/9/96	16:00	24.90	6053.1
8/10/96	16:00	24.92	6053.1
8/11/96	16:00	24.96	6053.0
8/12/96	16:00	25.08	6052.9
8/13/96	16:00	25.16	6052.8
8/14/96	16:00	25.18	6052.8
8/15/96	16:00	25.23	6052.8
8/16/96	16:00	25.21	6052.8
8/17/96	16:00	25.21	6052.8
8/18/96	16:00	25.39	6052.6
8/19/96	12:00	25.39	6052.6 *
8/19/96	16:00	25.42	6052.6
8/20/96	16:00	25.43	6052.6
8/21/96	16:00	25.60	6052.4
8/22/96	16:00	25.63	6052.4
8/23/96	16:00	25.71	6052.3
8/24/96	16:00	25.70	6052.3
8/25/96	16:00	25.73	6052.3
8/26/96	16:00	25.73	6052.3
8/27/96	16:00	25.79	6052.2
8/28/96	16:00	25.99	6052.0
8/29/96	16:00	26.02	6052.0
8/30/96	16:00	25.94	6052.1
8/31/96	16:00	26.02	6052.0
9/1/96	16:00	26.05	6051.9
9/2/96	16:00	26.15	6051.8
9/3/96	16:00	26.15	6051.8
9/4/96	16:00	26.11	6051.9
9/5/96	16:00	26.24	6051.8
9/6/96	16:00	26.41	6051.6
9/7/96	16:00	26.43	6051.6
9/8/96	16:00	26.47	6051.5
9/9/96	16:00	26.54	6051.5
9/10/96	16:00	26.62	6051.4
9/11/96	16:00	26.61	6051.4
9/12/96	15:55	26.52	6051.5 *
9/12/96	16:00	26.57	6051.4
9/13/96	16:00	26.56	6051.4
9/14/96	16:00	26.68	6051.3
9/15/96	16:00	26.77	6051.2
9/16/96	16:00	26.88	6051.1
9/17/96	16:00	26.95	6051.0
9/18/96	16:00	27.00	6051.0 *
9/19/96	16:00	27.05	6050.9
9/20/96	16:00	27.01	6051.0
9/21/96	16:00	27.05	6050.9
10/9/96	15:55	27.95	6050.1 *



ndwater in the Upper Big Hole basin, Montana.

Plate 2. Locations of ditch monitoring points in the upper Big Hole basin.




ANACONDA
PINTLER
RANGE
ANACONDA NATIONAL FOREST
CONTINENTAL DIVIDE
RAVALLI CO
BEAVERHEAD CO
DEER LODGE CO
BEAVERHEAD CO
BOUNDARY
Bitterroot River
East Fork
Fishtrap
Creek
NATIONAL FOREST BOUNDARY
Mussigbrod
Big Hole River
North Fork
6400
6300
6200
6100
6000
BIG HOLE
Wisdom
Wisdom Airport
BIG HOLE NATIONAL BATTLEFIELD
NEZ PERCE NATIONAL HISTORICAL PARK
Mud Lake
Odell Mountain
NATION

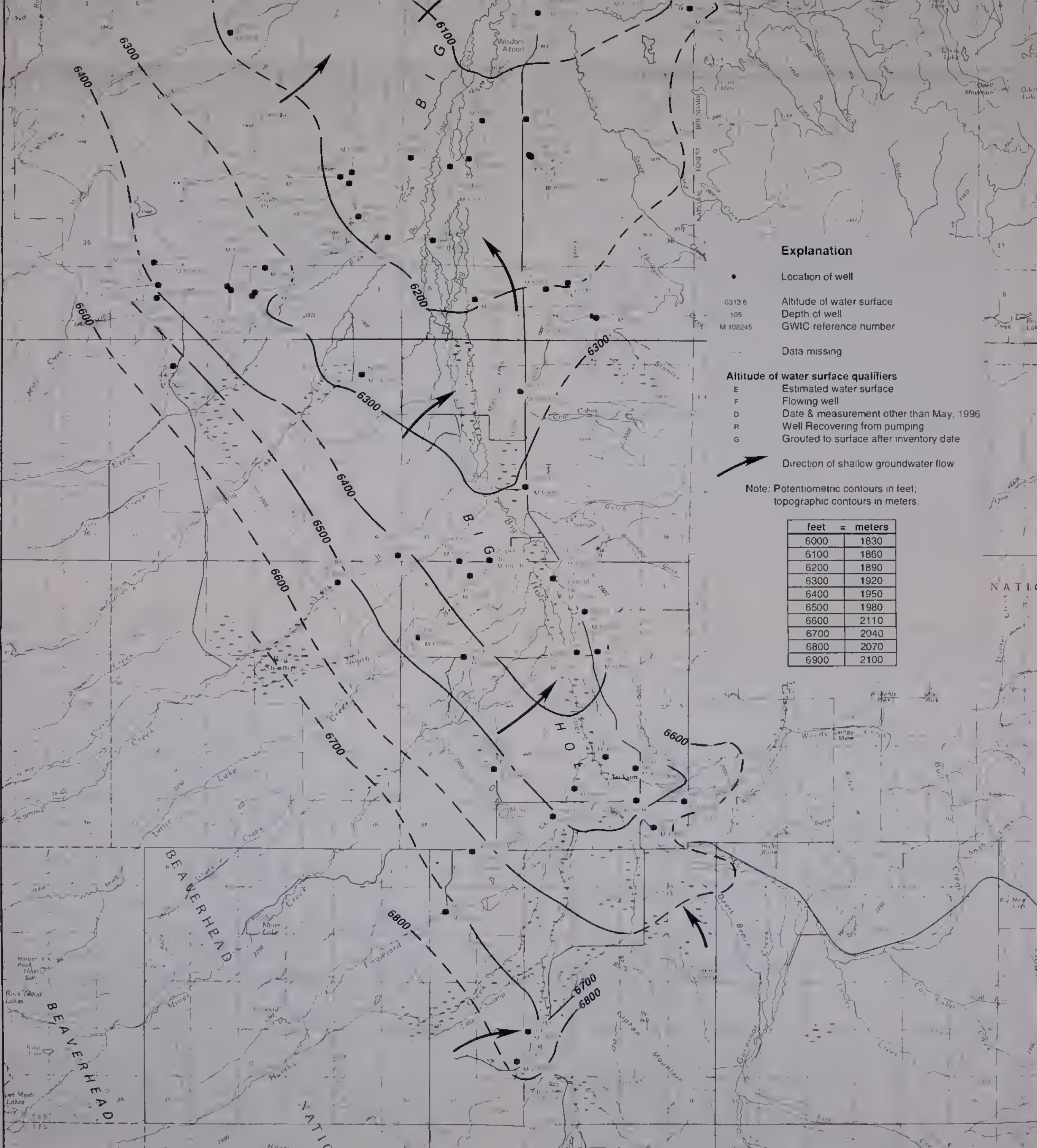
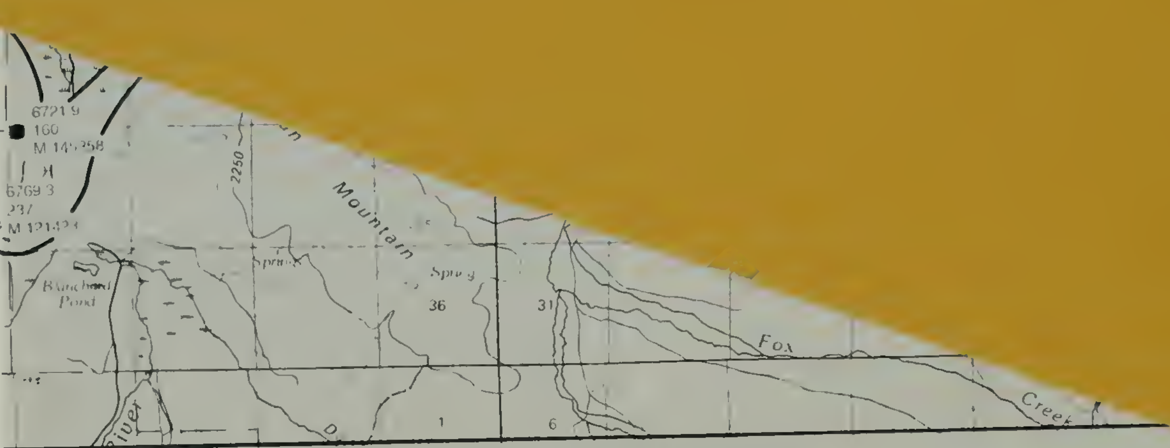


Plate 1: Potentiometric surface of shallow groundwater in the Upper Big Hole basin, Montana.



ndwater in the Upper Big Hole basin, Montana.